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NASCOR WOOD I FLOOR JOISTS

CANADIANA

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Alberta
MUNICIPAL AFFAIRS
Innovative Housing Grants Program

NASCOR WOOD I FLOOR JOISTS

MARCH, 1991

Prepared by:

Nascor Incorporated

The views and conclusions expressed and the recommendations made in this report are entirely those of the authors and should not be construed as expressing the opinions of Alberta Municipal Affairs.

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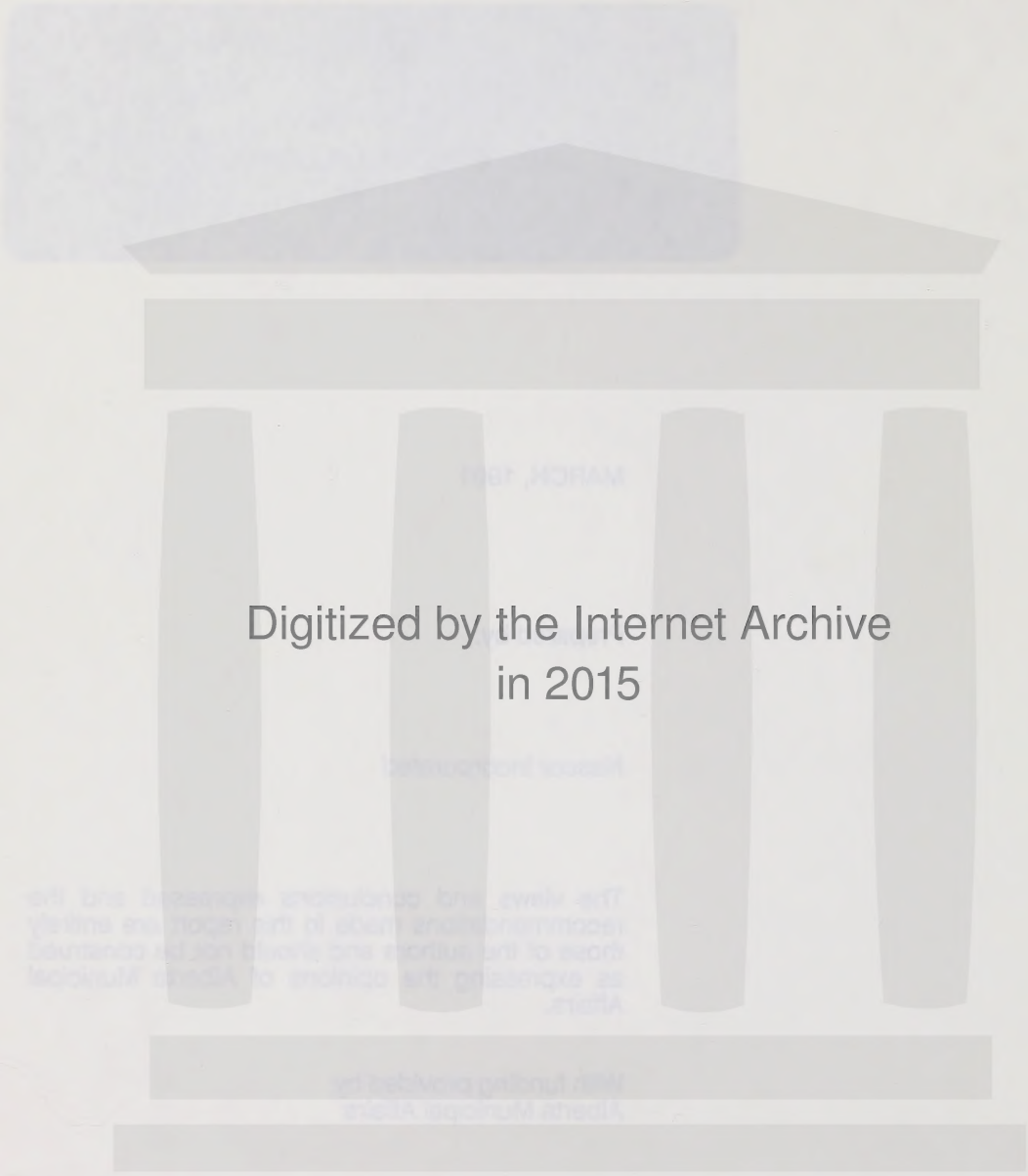

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FOREWORD

The project documented in this report received funding under the Innovative Housing Grants Program of Alberta Municipal Affairs. The Innovative Housing Grants Program is intended to encourage and assist housing research and development which will reduce housing costs, improve the quality and performance of dwelling units and subdivisions, or increase the long term viability and competitiveness of Alberta's housing industry.

The Program offers assistance to builders, developers, consulting firms, professionals, industry groups, building products manufacturers, municipal governments, educational institutions, non-profit groups and individuals. At this time, priority areas for investigation include building design, construction technology, energy conservation, site and subdivision design, site servicing technology, residential building product development or improvement and information technology.

As the type of project and level of resources vary from applicant to applicant, the resulting documents are also varied. Comments and suggestions on this report are welcome. Please send comments or requests for further information to:

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EXECUTIVE SUMMARY

Introduction

Nascor recognized a need in the residential construction industry for a new Wood I floor joist product that would be competitive with the pricing of conventional 2x10 (38x235mm) and 2x12 (38x286mm) wood floor joists; something that current Wood I products on the market have not accomplished. By developing the NJ10, NJ12, and NJS12 Wood I floor joists, Nascor has met this need and expects to not only capture a significant portion of the existing Wood I floor joist market but also to acquire a large share of the conventional wood floor joist market.

The advantages of the Nascor Wood I floor joists are many including the following:

i) stiffer floors,

ii) less squeaks,

iii) consistent high quality product,

iv) no waste,

v) efficient engineered designs,

vi) longer spans, and

vii) conventional joist hardware can be used (ie - joist hangers).

Testing Program

Warnock Hersey Professional Services Ltd. were engaged by Nascor to perform all necessary structural testing of the NJ10, NJ12, and NJS12 Wood I floor joists. Testing was in accordance with CCMC requirements for evaluation and Product Listing.

The test program consisted of pure bending tests of full span joists from which the stiffness (EI value) and the allowable bending moment capacity of the joists were determined, shear tests on short specimens to establish the allowable shear capacity of the web-to-chord joint, shear tests on short span joists to establish the allowable shear capacity of the web and the web-to-web joints, long term loading and unloading on pairs of full span joists to investigate creep performance, and vertical load tests on short specimens to establish bearing capacity.

Test Results

The test results were subjected to statistical analysis and used in accepted engineering formulae to obtain reliable structural capacities and properties of the joists. Allowable bending moment, allowable shear, the stiffness coefficient (EI value), and creep performance were established for each joist. These values all compared closely with values developed by theoretical analysis. Further analysis indicated the Nascor joists are capable of

longer spans than conventional wood floor joists while exhibiting greater stiffness.

The test results along with other supporting documents have been submitted to CCMC for evaluation and subsequent issue of a CCMC Product Listing.

1.0 INTRODUCTION

For many years, Alberta's residential construction industry has relied almost exclusively on conventional 38 x 235 mm (2 x 10) and 38 x 286 mm (2 x 12) Douglas Fir or Spruce-Pine-Fir (S-P-F) wood floor joists for residential floor construction.

During the past decade a new product, the composite Wood I floor joist, has been introduced to the market. In recent years, the Wood I joist has gained a significant share of the residential floor joist market. The reasons for its success can be summarized in three areas as follows:

(1) As many carpenters and builders are aware, the quality of lumber in general is declining. More and more, lumber mills are relying on second and third growth forest since much of the readily accessible old growth forests have already been cut. The remaining stands of old growth forests will probably disappear within the next ten to fifteen years.

The Wood I joist, on the other hand, is a product composed of smaller dimension lumber for its chords; therefore is not reliant upon the milling of large diameter trees. The web of the Wood I is composed of wood chips and strands which can

also be produced from small diameter trees. Additionally, the Wood I joist is an engineered product composed of only select wood materials and is manufactured under strict quality control programs. High quality, consistency, and predictability are therefore ensured, not only for the present, but also for the foreseeable future.

(2) Wood I joists exhibit superior structural performance compared to conventional wood floor joists. House designers therefore have the added flexibility of increased allowable spans under greater floor loads.

(3) The cost of obtaining suitable floor joist lumber has increased considerably. This has resulted in Wood I floor joists becoming increasingly cost competitive.

Recently, another development has affected the future use of the conventional wood floor joist in the residential construction industry. The 1990 National Building Code of Canada has significantly decreased the allowable spans of conventional wood joists (by up to 600 mm (24") or more in many cases). These reductions have no affect on the allowable spans of Wood I joists.

Based on all of the above, Nascor concluded that a Wood I joist design that incorporated savings in material costs with only a marginal decrease in structural capacity from comparable Wood I joists would have considerable impact on the conventional and Wood I floor joist market. Nascor therefore developed the NJ10, NJ12 and NJS12 Wood I floor joists.

The primary objective of this project was to carry out structural testing of the NJ10, NJ12 and NJS12 joists, both to verify design calculations and assumptions and to obtain the data necessary for an application for product evaluation to be prepared and submitted to the Canadian Construction Materials Centre of the National Research Council.

This report describes the products, applicable building code requirements, the test procedures utilized, the results of the tests, and the anticipated economic impact of the Nascor Wood I joists.

2.0 GENERAL PROJECT DESCRIPTION

2.1 Initial Product Development and Market Research

Nascor Incorporated has been involved with the residential construction industry for over eight years as a producer of prefabricated, energy efficient, exterior wall systems. Recent company market research revealed a number of interesting aspects relating to residential floor systems:

(1) Builders have noted that as the price of floor joist lumber has gone up, the quality of the lumber has gone down. This results in more waste.

(2) Homeowners are not generally satisfied with the stiffness of their floors in many cases. It is believed that this is due to two circumstances: the quality of available lumber has declined, and Building Code span tables utilized by builders to set floor joists sizes reflect minimum structural requirements and will not necessarily provide top notch floor stiffness performance.

(3) The 1990 National Building Code has implemented lower allowable stresses for floor joist lumber and has introduced vibration control criteria in the preparation of the allowable span

tables for floor joists. Allowable spans for floor joists have therefore been decreased by up to 24" (610 mm) or more in many cases. This directly affects builders and developers since standard floor layouts may now have to change to compensate for decreased allowable spans.

(4) It was recognized that the Wood I floor joists currently on the market would alleviate the problems discussed in items (1), (2) and (3) above. However, Wood I floor joists have not yet captured a substantial portion of the conventional market. The reason is simply one of cost. Wood I joists are still more expensive than conventional 2 x 10 (38 x 235 mm) and 2 x 12 (38 x 286 mm) wood joists. Additionally, builders balk at having to pay for a Wood I joist that can span up to 24 ft. (7.3 m) when a span of only 16 ft. (4.9 m) is required.

(5) Builders using the Wood I joists currently on the market have noted that the hardware associated with floor joists (such as joist hangers) has to be revised since the width of the Wood I joists (generally 89 mm (3 1/2") is different from that of conventional wood joists (38 mm 1 1/2")).

It was therefore concluded that the Nascor Wood I floor joist could compete very well with conventional wood floor joists if two objectives were addressed in their design: (1) competitive pricing and (2) similarity of dimension to conventional wood floor joists.

Therefore Nascor designed the NJ10, NJ12 and NJS12 Wood I floor joists to meet these objectives. These joists are intended to replace conventional 2 x 10 (38 x 235 mm) and 2 x 12 (38 x 286 mm) wood floor joists with better performance than conventional joists and with more competitive pricing than other Wood I products currently on the market.

2.2. Qualification Testing of the Nascor Wood I Floor Joists

The Wood I floor joist is not covered in the National Building Code of Canada. Therefore code officials require that such a product undergo an evaluation of structural performance before allowing it to be used in any structure.

The Canadian Construction Materials Centre (CCMC) of the National Research Council of Canada performs these evaluations of building products and ensures the product conforms to the intent of the National Building Code.

In order to obtain a Product Listing by CCMC, the Nascor joists were required to undergo a series of structural tests by an accredited laboratory. Warnock Hersey Professional Services Ltd. in Coquitlam, B.C. were retained by Nascor to carry out these tests.

The scope of this project encompassed the structural testing as required by CCMC. The results of the tests along with other required documentation will be submitted to CCMC for evaluation and subsequent product listing.

3.0 PRODUCT DESCRIPTION

3.1. Nascor NJ10 Wood I Floor Joist

The NJ10 joist (Figure 3.1) was designed to replace the conventional 38 x 235 mm (2 x 10) wood floor joist and is composed of the following materials:

(i) Top and Bottom Chords - 38 x 64 mm (2 x 3), S-P-F, 2100 MSR lumber

(ii) Web - 9.5 mm (3/8") thick oriented strand board (OSB) rated as "Struc One Web Stock" by Weyerhaeuser

(iii) Glue - phenol resorcinol

As opposed to traditional Wood I design, the top and bottom chords are oriented in the vertical plane rather than the horizontal plane.

The overall dimensions of the NJ10 are 38 mm (1 1/2") wide by 241 mm (9 1/2") deep. The width of 38 mm (1 1/2") was chosen to match that of conventional wood floor joists so that joist layout and joist hardware (ie. - joist hangers) are compatible with conventional construction. The slight increase in depth was chosen for structural reasons but does not have any significant effect on compatibility with conventional construction practices.

The web-to-chord connection is accomplished by inserting tapered web edges into a 12.9 mm (1/2") deep slot with tapered sides in the chords. The connection is held together by a structural waterproof glue.

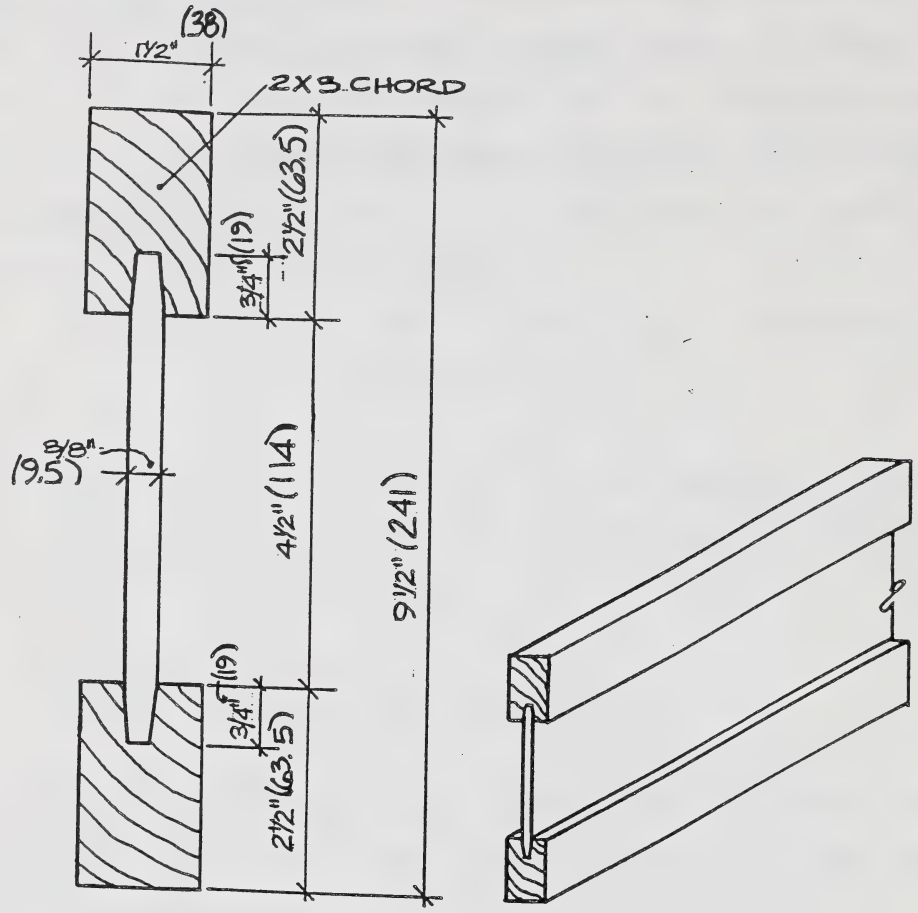


FIGURE 3.1

(METRIC DIMENSIONS IN BRACKETS)

NASCOR SYSTEM™	NASCOR JOIST NJ10

CHORD: 2X3 2100 MACHINE STRESS RATED (M.S.R.) LUMBER

WEB: 3/8" ORIENTED STRAND BOARD (O.S.B)

NASCOR INCORPORATED
7803P - 35 ST. S.E.
CALGARY, ALTA.
T2C 1V3
(403) 279-1966

DATE: 20APR90	REV.:	SCALE: NTS DWN BY: HJP	DWG. NO. 1

3.2 Nascor NJ12 Wood I Floor Joist

The NJ12 joist (Figure 3.2) was designed to replace the conventional 38x x 286 mm (2 x 12) wood floor joist and is composed of the following materials:

(i) Top and Bottom Chords - 38 x 64 mm (2 x 3), S-P-F, 2100 MSR lumber

(ii) Web - 9.5 mm (3/8") thick oriented strand board (OSB) rated as "Struc One Web Stock" by Weyerhaeuser.

(iii) Glue - phenol resorcinol

As opposed to traditional Wood I design, the top and bottom chords are oriented in the vertical plane rather than the horizontal plane.

The overall dimensions of the NJ12 are 38 mm (1 1/2") wide by 302 mm (11 7/8") deep. The width of 38 mm (1 1/2") was chosen to match that of conventional wood floor joists so that joist layout and joist hardware (ie. - joist hangers) are compatible with conventional construction. The slight increase in depth was chosen for structural reasons but does not have any significant effect on compatibility with

conventional construction practices.

The web-to-chord connection is accomplished by inserting tapered web edges into a 12.9 mm (1/2") deep slot with tapered sides in the chords. The connection is held together by glue.

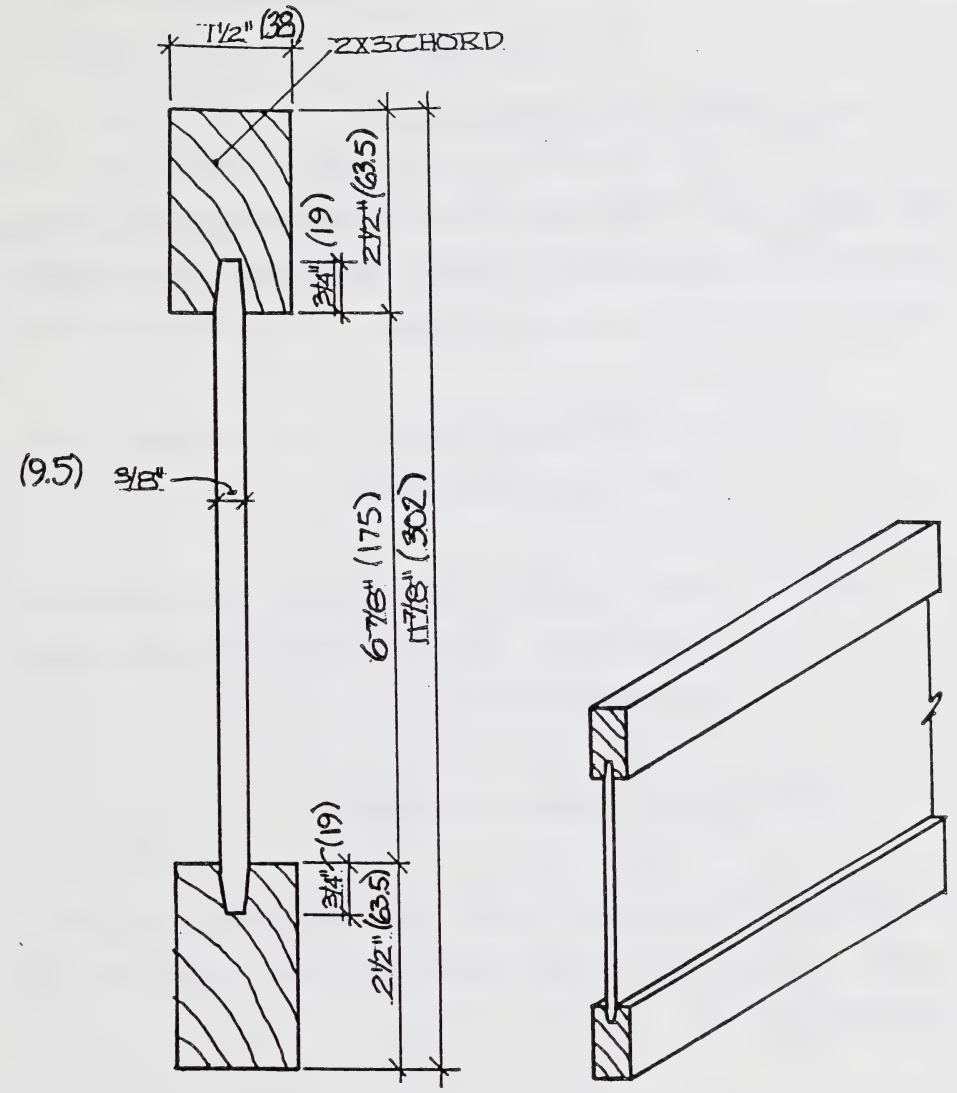


FIGURE 3.2

(METRIC DIMENSIONS IN BRACKETS)

NASCOR SYSTEM™	NASCOR JOIST NJ12

CHORD: 2X3 2100 MACHINE STRESS RATED (M.S.R.) LUMBER

WEB: 3/8" ORIENTED STRAND BOARD (O.S.B.)

NASCOR INCORPORATED
7803P - 35 ST. S.E.
CALGARY, ALTA.
T2C 1V3
(403) 279-1966

DATE: 12 JUN 90	REV.:	SCALE: NTS DWN BY: HJP	DWG. NO. 3

3.3. Nascor NJS12 Wood I Joist

The NJS12 joist (Figure 3.3) was designed to replace the conventional 38 x 286 mm (2 x 12) wood floor joist and is composed of the following materials:

(i) Top and Bottom Chords - 38 x 89 mm (2 x 4), S-P-F, 2100 MSR lumber

(ii) Web - 9.5 mm (3/8") thick oriented strand board (OSB) rated as "Struc One Web Stock" by Weyerhaeuser

(iii) Glue - phenol resorcinol

As opposed to traditional Wood I design, the top and bottom chords are oriented in the vertical plane rather than the horizontal plane.

The overall dimensions of the NJS12 are 38 mm (1 1/2") wide by 302 mm (11 7/8") deep. The width of 38 mm (1 1/2") was chosen to match that of conventional wood floor joists so that joist layout and joist hardware (ie. - joist hangers) are compatible with conventional construction. The slight increase in depth was chosen for structural reasons but does not have any significant effect on compatibility with

conventional construction practices.

The web-to-chord connection is accomplished by inserting tapered web edges into a 12.9 mm (1/2") deep slot with tapered sides in the chords. The connection is held together by glue.

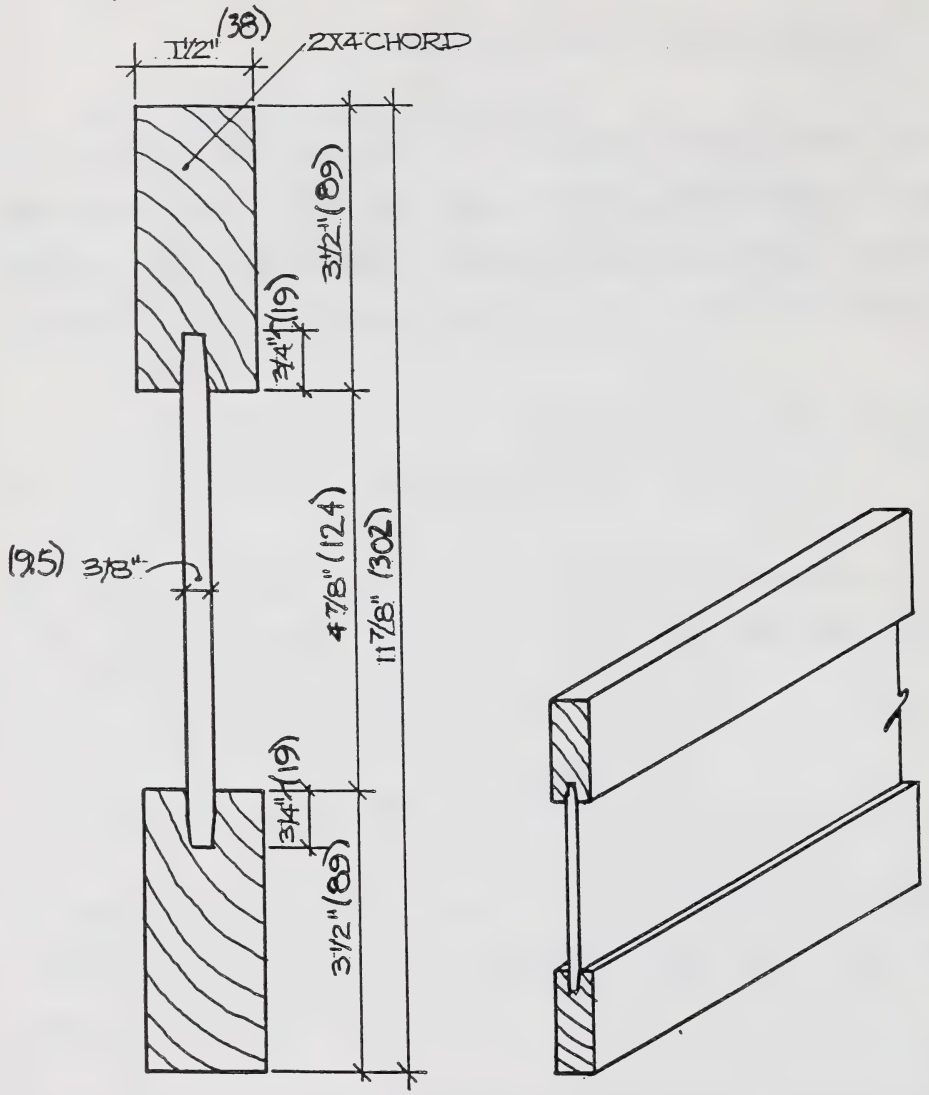


FIGURE 3.3

(METRIC DIMENSIONS IN BRACKETS)

NASCOR SYSTEM	NASCOR JOIST NJS12

CHORD: 2X4 2100 MACHINE STRESS RATED (MSR.) LUMBER

WEB: 3/8" ORIENTED STRAND BOARD (OSB)

NASCOR INCORPORATED
7803P - 35 ST. S.E.
CALGARY, ALTA.
T2C 1V3
(403) 279-1966

DATE: 20APR90	REV.:	SCALE: NTS DWN BY: HJP	DWG. NO. 2

4.0 BUILDING CODE AND REGULATORY REQUIREMENTS AND NASCOR COMPLIANCE

4.1 National Building Code of Canada

Although the Nascor Wood I floor joists are intended for use in residential structures, Part 9 of the Code covers conventional wood products and construction practices only. Therefore code officials require that the NJ10, NJ12, and NJS12 Wood I floor joist systems be designed in accordance with Part 4 and Section 2.3.4 of the Code. Part 4 requires that structural wood members be designed in accordance with CSA Standard CAN3-086.1, "Engineering Design in Wood". Section 2.3.4 requires that the design be done and certified by a Professional Engineer.

4.2 Canadian Construction Materials Centre (CCMC)

At the time of this writing, CCMC has not developed any formal conformance requirements specifically for Wood I joists but is in the process of doing so. It was established through discussions with CCMC that testing and analysis of Nascor's Wood I joists, performed in accordance with ASTM Standard D5055-90, "Standard Specifications for Establishing and Monitoring Structural Capacities of Prefabricated Wood I Joists", is acceptable to CCMC for evaluation and product listing purposes. However, CCMC has

one test requirement that is slightly different from that outlined in the ASTM Standard. CCMC requires the joists be subjected to a creep test in accordance with the procedures outlined in CCMC's "Technical Guide for Prefabricated, Structural Wood Beams and Joists" (see Appendix A).

CCMC also requires, as supporting documents for a Product Listing application, a quality control manual for the manufacturing process of the Wood I joists, an installation guidelines booklet for the end users of the joists, and confirmation that an accredited third party quality assurance agency will monitor Nascor's manufacturing processes and quality control program.

4.3. Nascor Compliance to Building Code and Product Listing Requirements

To satisfy the requirements of the National Building Code and CCMC's requirements for a Product Listing, structural testing of the NJ10, NJ12 and NJS12 Wood I joists was carried out in accordance with ASTM Standard D5055-90 from which allowable structural capacities were established. Based on these capacities, allowable load and allowable span tables for the joists were developed, and certified by a Professional Engineer. Allowable span tables were based on the live and dead structural loading requirements outlined in Part 4 of the National Building Code of Canada

for residential applications. Refer to Appendices B and C for these tables. In addition, an installation guidelines booklet was prepared and was also certified by a Professional Engineer. The tables and installation guidelines booklet will be provided to building officials to facilitate assessment of conformance during their site inspections. Additionally, to satisfy CCMC requirements for a Product Listing Nascor Incorporated will maintain the quality of the joists throughout their manufacturing process by having Warnock Hersey Professional Services Ltd. act as a third party quality assurance agency to monitor Nascor's quality control program.

5.0. STRUCTURAL TESTING PROCEDURES

Structural testing of the Nascor NJ10, NJ12, and NJS12 Wood I floor joists was based on the requirements of the ASTM Standard D5055, "Standard Specifications for Establishing and Monitoring Structural Capacities of Prefabricated Wood I Joists". The testing was performed by Warnock Hersey Professional Services Ltd. in Coquitlam, B.C. and their test report is included in Appendix A.

5.1 Allowable Bending Moment Capacity and Stiffness Capacity

To establish the allowable bending moment and stiffness capacities of the Nascor Wood I joists, each joist was supported on pinned supports which could rotate in any direction and was subjected to two equal point loads located at the one-third span points of the joist. The joists were loaded until failure with the load recorded at incremental centre span deflections. A total of 28 samples of each joist type were tested in this manner. The clear span between supports was 171" (4334 mm) for the NJ10 and 213" (5410 mm) for the NJ12 and NJS12 which translates into a span-to-depth ratio of 18, the ratio recommended by ASTM D5055.

To simulate actual field conditions of lateral restraint, the joists were laterally restrained at 24" (610 mm) on centre. A sketch of the test set-up is shown in Figure 5.1.

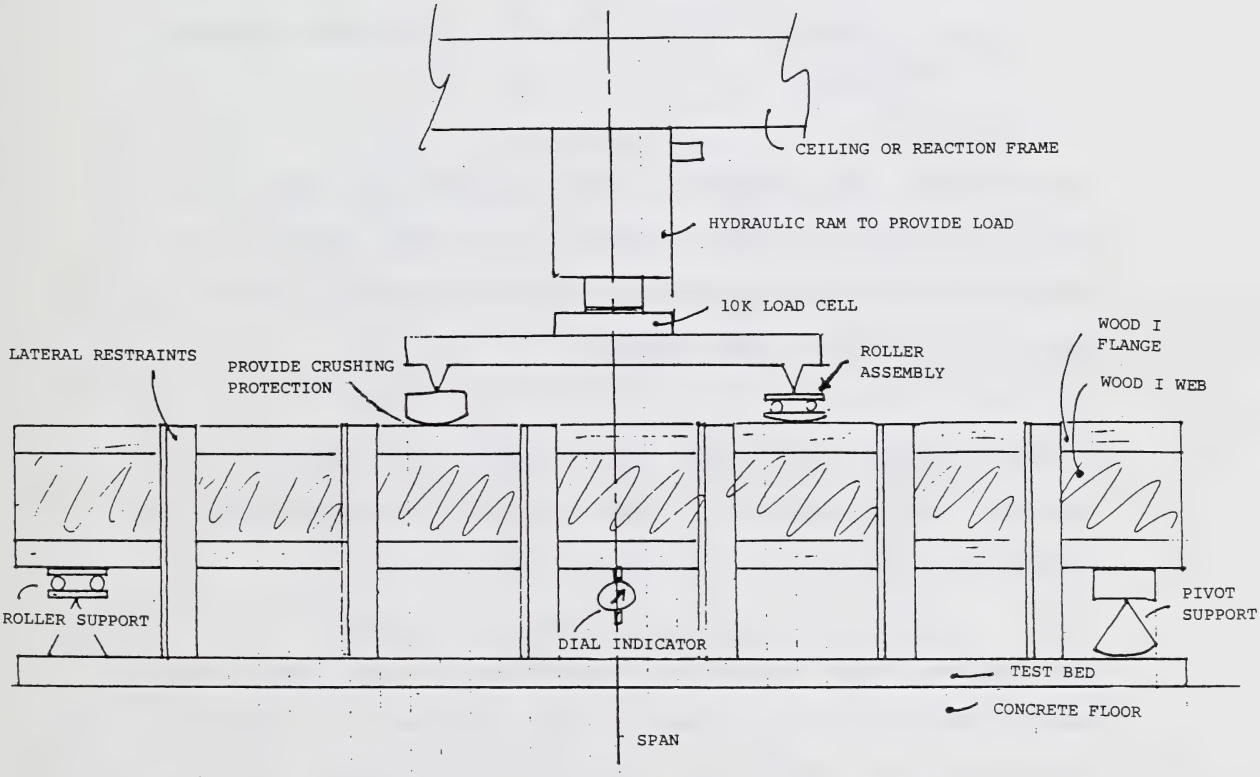


Figure 5.1 Bending Test Diagram

5.2 Allowable Shear Capacity

To establish the allowable shear capacity of the Nascor Wood I joists, two separate test procedures were used as outlined in the subsections below.

5.2.1. Allowable Shear Capacity of the Web-to-Chord Joint

To establish the allowable shear capacity of the web-to-chord joint for the Wood I joists, four inch (102 mm) long samples were cut at random from full length NJ12 joists. A total of 15 samples were tested.

A sample length of 4" (102 mm) was chosen so that the load applied would produce a web-to-chord joint failure as opposed to simply crushing of the web.

The samples were tested by supporting the top and bottom chords and applying a load to the web only in order to force the web through the chords. (See Figure 5.2.1.). The samples were loaded until failure with the failure load recorded as well as the failure mode.

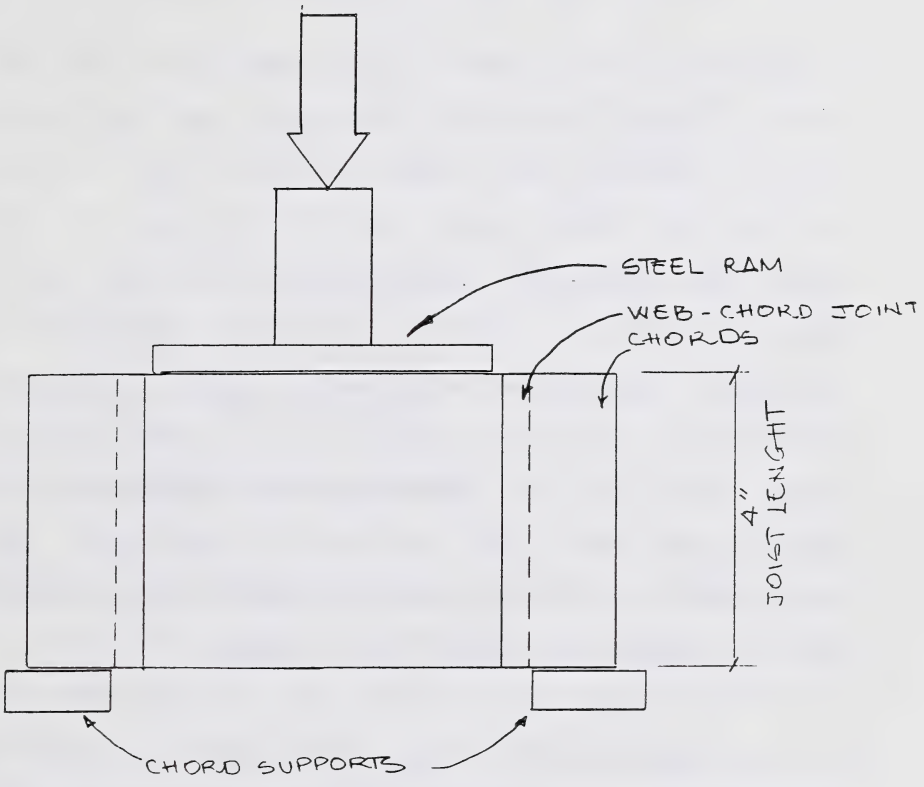


Figure 5.2.1 Web-To-Chord Shear Test Diagram

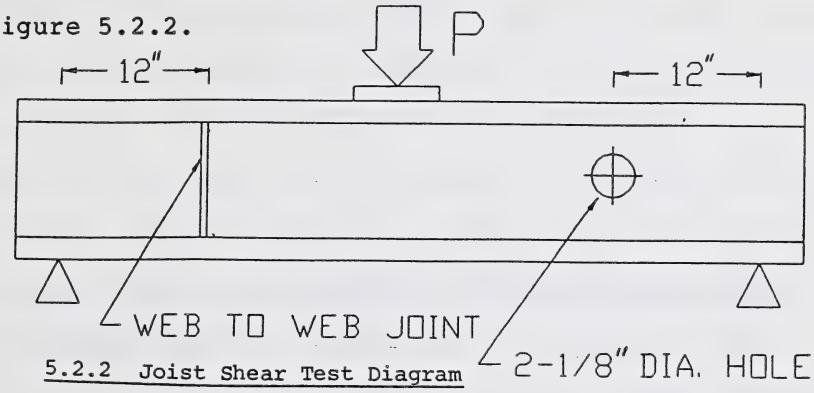
5.2.2. Allowable Shear Capacity of the Web and the Web-to-Web Joints

To establish the allowable shear capacity of the web (ie. shear through thickness capacity) and the web-to-web joints, (splices) short sample lengths of 42" (1067 mm) for the NJ12 and NJS12 joists and 36" (914 mm) for the NJ10 joist were chosen to ensure shear failures in lieu of bending failures. Sixteen samples of NJ10 and fifteen samples of the NJ12 and NJS12 were tested. The tests were conducted by placing the samples on pinned supports which could rotate in any direction and applying a single concentrated load to the top chord at mid-span. The load was applied to a 6" (150 mm) wide steel plate on top of the joist to avoid crushing of the top chord.

To test the effect of holes in the web, a 2 1/8" (54 mm) diameter hole was drilled through the web of each sample at a distance of 12" (305 mm) from one end of the joist. This was considered to be the worst case scenario.

To test the combined effect of a web-to-web joint and a hole in the joist, each sample had a web-to-web joint located at a distance of 12" (305 mm) from the opposite end of the sample from where the hole was drilled. This was considered to be the worst case scenario.

Each sample was loaded until failure. The failure load and the mode of failure were recorded. A graphic description of the failure modes is included with Warnock Hersey's report in Appendix A. A sketch of the test set-up is shown in Figure 5.2.2.



5.2.2 Joist Shear Test Diagram

5.3 Allowable Bearing Capacity

To establish the allowable bearing capacity of the Nascor joists with and without stiffeners, a total of thirty samples were tested. Ten samples had no stiffeners, ten samples had a 15.9 mm (5/8") thick OSB stiffener attached to one side of the web, and ten samples had 15.9 mm (5/8") thick OSB stiffeners attached to both sides of the web. The test samples were 76 mm (3") long cut at random from full length joists. The web stiffeners were the same length as the samples and were attached to the webs using two 38 mm (1 1/2") common nails per side. The stiffeners were attached tight to the bottom chord but a 1/8" gap was left between the top chord and the stiffener (See Figure 5.3 (a)).

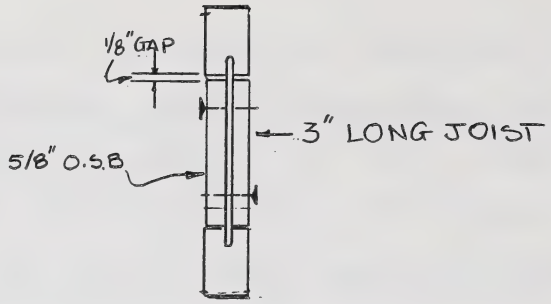
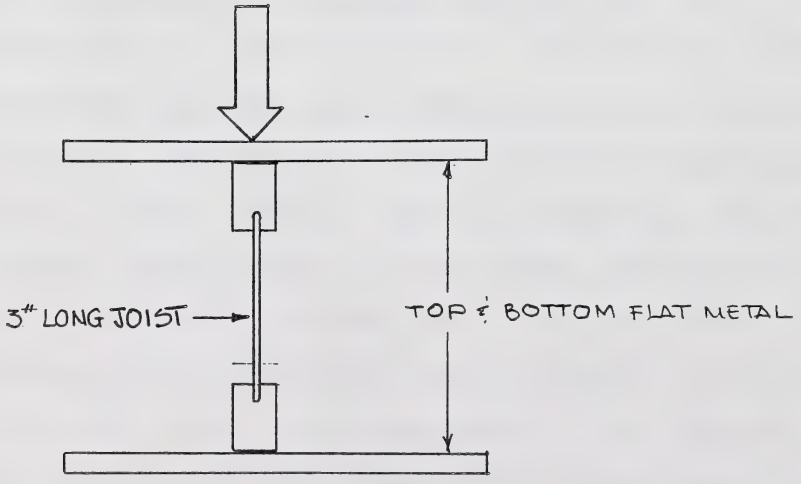


Figure 5.3(a) Stiffener Attachment Details

The samples were tested by placing the bottom chord on a flat metal surface. The sides of the samples were restrained against lateral movement. A load was applied to the top chord until failure was achieved. The failure load was recorded. See Figure 5.3(b) for a sketch of the test set up.



5.3(b) Bearing Test Diagram

5.4 Creep Performance

Creep performance tests were done in accordance with the Canadian Construction Materials Center's (CCMC) "Technical Guide for Prefabricated, Structural Wood Beams and Joists, Masterformat Section 06915, January 15, 1990". The purpose of the tests was to establish that each Nascor Wood I joist's creep performance under load versus time was within the limits set by CCMC. The results of these tests are presented in Appendix E.

The creep test was conducted on a panel consisting of a pair of joists spaced at 24" (610 mm) on centre and sheathed with 3/4" (18.5 mm) thick Douglas Fir plywood in 24"x48" (610x1220 mm) sheets. The plywood was fastened with 2" (51 mm) common nails spaced at 6" (150 mm) on centre. The joists were cross braced at mid span and the ends of the joists were restrained from spreading apart by the attachment of small strips of plywood. Three such panels were tested for each Nascor Wood I joist. The span of the NJ10 panels was 186" (4724 mm). The span of the NJ12 panels was 210" (5334 mm). The span of the NJS12 panels was 222" (5639 mm).

To measure deflection at mid span of the panels, a wire was strung along one side of the panel and kept taut by

attaching it to springs at either end. A graduated scale was attached to the panel at mid span so that deflection could be read. To avoid parallax errors in reading the scale, the scale was mounted to a mirror and this assembly was mounted at mid span of each panel.

Loading of the panels was accomplished by placing standard 8"x8"x16" (203x203x406 mm) concrete blocks of known weight on top of the panels.

Testing was carried out in seven steps as outlined below:

Step 1 - set panel and obtain a zero reading on the deflection scale.

Step 2 - load panel with concrete blocks to 10 psf (0.50 kN/m^2) and read deflection after a time period of 300 seconds.

Step 3 - load panel with more concrete blocks to 21 psf (1.0 kN/m^2) and read deflection after a time period of 300 seconds.

Step 4 - load panel further to 63 psf (3.0 kN/m^2) and read deflection after a time period of 300 seconds.

Step 5 - read deflection after a period of 24 hours with same load on panel from Step 4.

Step 6 - remove all load from panel and read deflection after a time period of 300 seconds.

Step 7 - load panel with concrete blocks to a load of 125 psf (6.0 kN/m^2) and maintain for 24 hours to determine whether the panel could carry the load without failure.

6.0 DISCUSSION OF STRUCTURAL TESTING RESULTS

6.1 Allowable Bending Moment Capacity

To establish a statistically reliable allowable bending moment capacity, 28 samples of each Wood I joist were tested. This sample size was specified in ASTM D5055 and is the minimum required to achieve a reliable statistical confidence level for this type of product and testing procedure.

Warnock Hersey Professional Service Ltd. established the allowable bending moment capacities for the NJ10, NJ12, and NJS12 Wood I joists in accordance with clause 6.3.3.3. in ASTM D5055. This clause requires moment capacity to be determined by non-parametric statistics and to be based on the lower 5% tolerance limit with 75% confidence and divided by a safety factor of 2.10. The non-parametric statistical approach is generally more conservative than a parametric approach and can be more accurate especially when the sample size is comparatively small as is the case with a sample size of 28.

Warnock Hersey calculated the allowable bending moment capacity based on ASTM Standard D 2915-84, "Standard Method for Evaluating Allowable Properties for Grades of

Structural Lumber".

Section 4.5 in this standard outlines the procedure by which the appropriate statistical value for moment capacity is calculated. According to section 4.5 and Table 2, when 28 samples are tested, the first order statistic shall be the value used for the 5% nonparametric tolerance limit and 75% confidence level.

The order statistic is defined by ranking the sample test values, beginning with the smallest value. The first order statistic, then, is the smallest sample test value.

Therefore the allowable bending moment capacity for each joist was established by selecting the lowest ultimate failure load out of the 28 samples tested for each joist and then dividing this number by 2.10. This number (N) was then used in the standard, beam bending moment formula for two point loading at 1/3 spans, shown below, to arrive at the allowable bending moment.

$$M = N/2 \times L/3 = PL/3$$

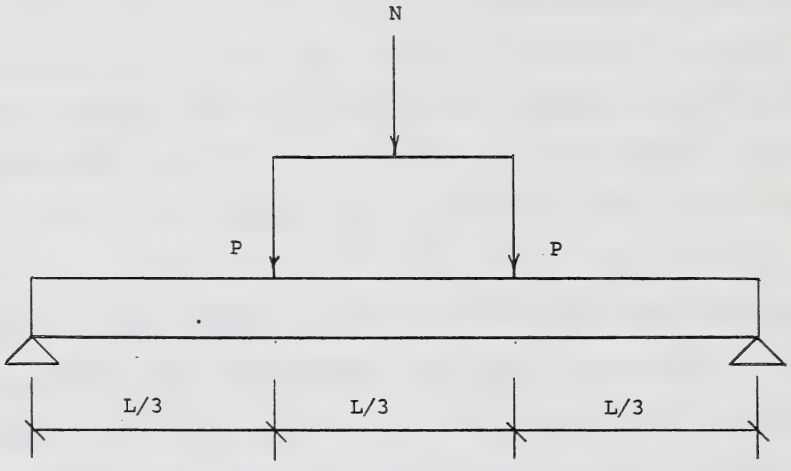
Where:

M - is the allowable bending moment

N - is the statistical load value as calculated by warnock Hersey

L - is the clear span between the supports at which the joists were tested. (ex. - 213")

P = N/2



L = 213" (5410mm)

Figure 6.1 Bending Test Load Diagram

Table 6.1(a) below summarizes the allowable bending moment capacity for the NJ10, NJ12 and NJS12 Wood I joists as calculated by ..arnock Hersey.

Table 6.1(a) - Allowable Bending Moment Capacity

JOIST	SPAN	N		ALLOWABLE BENDING MOMENT	
	(in)	(lbs)	(kN)	(lb-ft)	(N-m)
NJ10	171	2370	10.5	2681	3635
NJ12	213	3920	17.4	5524	7490
NJS12	213	3925	17.5	5529	7496

A comparison of the allowable bending moment capacities derived from the test results to those calculated by a theoretical analysis is shown in Table 6.1(b).

The theoretical values were calculated based on the section modulus of the member and the allowable tensile stress of the bottom chord in accordance with the standard beam formula given below:

$$M = F_t \times S$$

Where:

M = allowable bending moment

Ft = allowable tensile stress (working stress design)

= 1566 psi (10.8 MPa) from CAN3-086-M84

S = section modulus

= 20.16 $in.^4$ (330,363 mm^4) for NJ10

= 28.41 $in.^4$ (465,556 mm^4) for NJ12

= 32.81 $in.^4$ (537,660 mm^4) for NJS12

Note: in the calculation of S, the Web was transformed by a factor, T, where $T = \frac{E\ (WEB)}{E\ (CHORD)}$

Table 6.1(b) - Test Versus Theoretical Moment Capacities

JOIST	ALLOW.THEORETICAL MOMENT		ALLOW.MOMENT FROM TESTS	
	(lb-ft)	(N-m)	(lb-ft)	(N-m)
NJ10	2631	3567	2681	3635
NJ12	3708	5027	5524	7490
NJS12	4282	5806	5529	7496

In all cases the theoretical values were less than those derived from testing. The difference can be partially explained by noting that theoretical values are based on the bending resistance of the chords of the Wood I only; however, this is probably conservative since the web must also provide some bending resistance.

6.2 Stiffness Capacity

The stiffness capacity of a structural member is generally expressed as "EI"; the product of the modulus of elasticity, E, times the moment of inertia, I, of the member. The EI value can also be determined from the slope of the load versus deflection curve. The EI values for the NJ10, NJ12, and NJS12 Wood I joists were developed by Warnock Hersey from the same test data used to establish the allowable bending moment capacities. A linear regression (method of least squares) was performed on the load versus deflection data for each sample to establish the "best fit" line. The slope of this line, S, was used in the formula below to establish the stiffness capacity (EI) for each sample. The formula given below was derived by the Council of Forest Industries (COFI) of British Columbia in their published booklet "Design of Glued and Nailed Plywood Web Beams." Total deflection of a Wood I member is a combination of deflection due to bending and deflection due to shear; thus the two part equation.

$$\text{Deflection} = \frac{23PL^3}{648EI} + \frac{EwCPLh^2K}{GwEI}$$

$$EI = \frac{23SL^3}{648x2} + \frac{EwCLh^2KS}{2\,Gw}$$

Where:

S = slope of load versus deflection curve (from linear regression analysis), lb/in

L = span of member,in

Ew = 0.650×10^6 psi (4482 MPa)

= modulus of elasticity for edgewise bending for the web (as published by Weyerhaeuser)

C = 0.166

= two point load coefficient (from Figure 6 in COFI's booklet)

h = height of the Wood I joist (see Section 3.0),in

K = section shear constant from Figure 6 in COFI's booklet

K = 0.285 for NJ10

K = 0.285 for NJ12

K = 0.270 for NJS12

Gw = 0.190×10^6 psi (1310 MPa)

= web shear modulus (as published by Weyerhaeuser)

The EI for each sample was computed by the above formula. The mean EI of the 28 samples for each joist was selected as the stiffness capacity of the joist.

The EI values established for each joist are outlined in Table 6.2(a) below:

Table 6.2(a) - Stiffness Capacity

Joist	Stiffness Capacity, EI	
	lbs - in^2 x 10^6	N - mm^2 x 10^{11}
NJ10	169	4.85
NJ12	291	8.35
NJS12	308	8.84

A comparison of the stiffness capacities of the NJ10, NJ12, and NJS12 Wood I joists derived from the test results to the capacities determined from a theoretical analysis are outlined in Table 6.2 (b).

The theoretical values are based on the gross moment of inertia of the joists (ie - the web is included) and the

modulus of elasticity of the chords.

$$(EI)\ joist = Ec \times Ig$$

where Ec = Modulus of elasticity of the chord

= 1.80×10^6 psi (10,800 MPa) from CAN 3 - 086-M84

Ig = gross moment of inertia

= 96.81 $in.^4$ (40.30×10^6 mm^4) for NJ10

= 172.37 $in.^4$ (71.75×10^6 mm^4) for NJ12

= 196.95 $in.^4$ (81.98×10^6 mm^4) for NJS12

Note: In the calculation of I, the web was transformed by a factor, T, where $T = \frac{E\ (web)}{E\ (Flange)}$

By this factor, the web is transformed into an equivalent amount of material with the same E value as the chords.

Table 6.2(b) - Comparison of Theoretical Versus Test EI Values

Joist	Theoretical EI		EI From Tests	
	lbs - in^2	N - mm^2	lbs - in^2	N - mm^2
NJ10	$174x10^6$	$4.99x10^{11}$	$169x10^6$	$4.85x10^{11}$
NJ12	$310x10^6$	$8.90x10^{11}$	$291x10^6$	$35x10^{11}$
NJS12	$353x10^6$	$1.01x10^{11}$	$308x10^6$	$8.84x10^{11}$

In all cases, the theoretical values of EI are greater than those determined from testing. The explanation for this is the span-to-depth ratios at which the joists were tested should have been greater; say a span-to-depth ratio of 21. A ratio of 21 may provide a truer EI since the longer the span tested, the greater the value of EI obtained. ASTM Standard D2915 suggests in clause 4.3 that a ratio of 21 be used in tests to establish the modulus of elasticity of sawn lumber.

6.3 Allowable Shear Capacity

6.3.1 Allowable Shear Capacity for the Web-to-Chord Joint

As noted in Section 5.2.1, 15 samples were cut at random from full length NJ12 joists. Since the joint configuration for the NJ10, NJ12, and NJS12 Wood I joists are identical, only samples from the NJ12 were considered necessary. Figure 6.3.1 shows the typical joint configuration and dimensions.

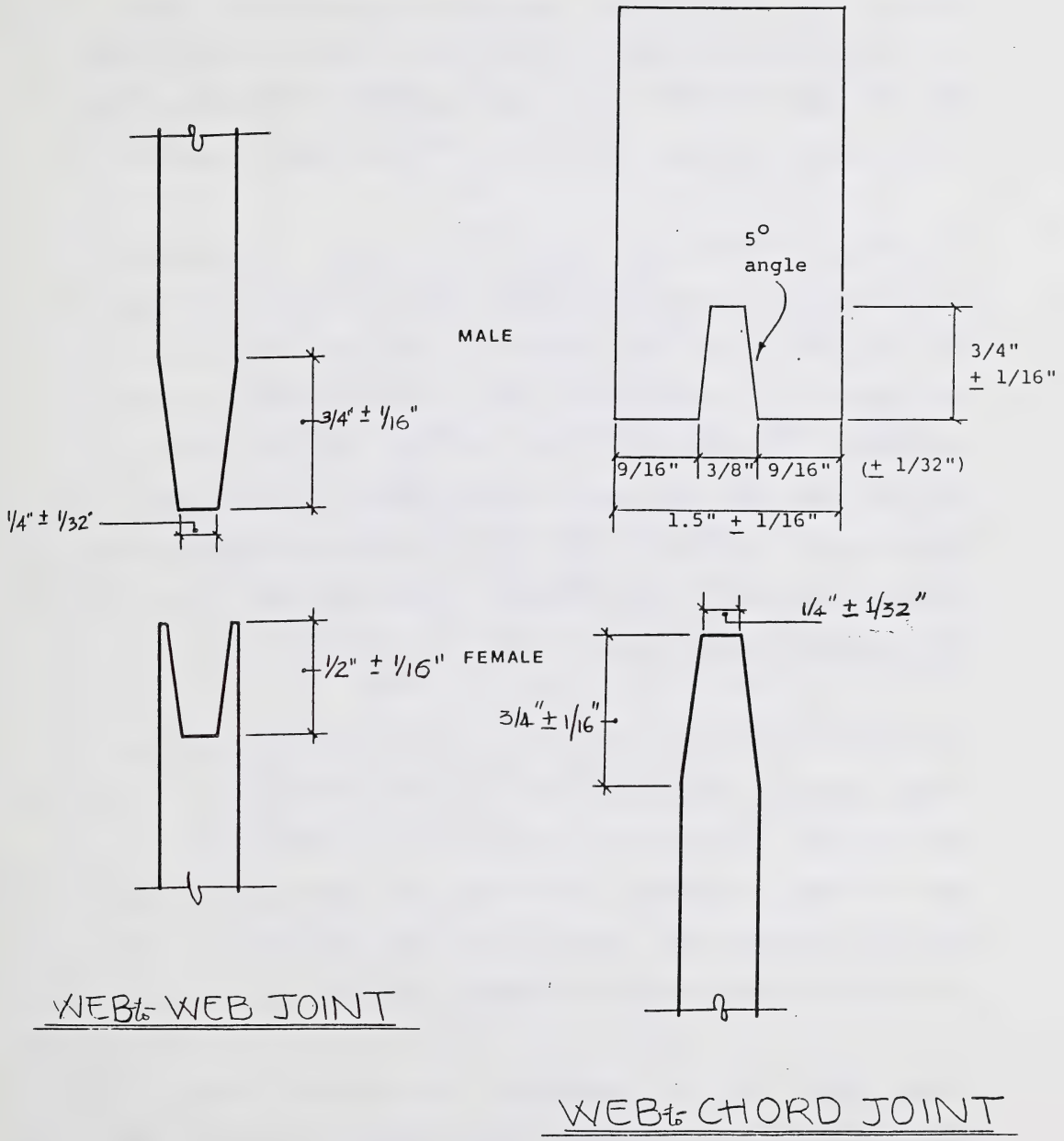


Figure 6.3.1 Joint Configuration

The test procedure described in Section 5.2.1 was chosen because web-to-chord shear capacity is essentially a test of the glue bond strength in the joint. Theoretically, the joint failure should be a wood failure; either the OSB fibres should separate or the chord fibres should separate.

As noted in the Warnock Hersey test report, (See Appendix D) about half the failure modes recorded (8 samples) were wood failures. The other samples (7 samples) failed by the load applicator crushing the web. Although this cannot be considered a web-chord joint failure, it did serve to indicate that the web would crush before a joint failure would occur. Therefore, the failure load recorded would be conservative since the web-chord joint had not failed at the recorded failure load.

Warnock Hersey determined the allowable web-to-chord shear stress capacity by dividing the lowest failure load by the area of glue line (joint contact area). This value was then divided by a safety factor of 2.10. The value derived from this process was 126 psi (0.87 MPa) and will be used for the NJ10, NJ12, and NJS12 Wood I joists.

Since there is no reliable theoretical method of determining the web-to-chord shear stress capacity, none was attempted. Therefore, an actual versus theoretical

comparison can not be made.

To arrive at the allowable shear capacities in Table 6.3.1, the following formula from COFI's "Design of Glued and Nailed Plywood Web Beams" was used:

$$V = \frac{Igl}{Qc} v$$

V = allowable shear capacity, lb

Ig = gross moment of inertia (see section 6.2 for values for the Wood I joists)

l = length of web-chord contact (glue line length)
= 1.75 in. (44.4 mm)

Qc = 13.13 in.3 (215,162 mm3) for NJ10
= 17.58 in.3 (288,085 mm3) for NJ12
= 21.98 in.3 (360,188 mm3) for NJS12
= first moment of chord areas about the neutral axis.

v = allowable web-chord shear stress
= 126 psi (0.87 MPa)

Table 6.3.1 - Allowable Shear Capacities

Joist	Allowable Shear Capacity	
	lbs.	kN
NJ10	1626	7.23
NJ12	2162	9.62
NJS12	1976	8.79

6.3.2 Allowable Shear Capacity of the Web and the Web-to-Web Joints

Structural testing to establish the allowable shear capacity of the web itself, the web-to-web joints, and of the web with a 2 1/8" (54 mm) diameter hole through it were done on joist spans that would provide the best chance for a shear failure rather than a bending failure. A span of 36" (914 mm) was chosen for the NJ10 and a span of 42" (1067 mm) was chosen for the NJ12 and NJS12.

These methods also tested the shear capacity of the web-to-

chord joint. The modes of failure shown in the Warnock Hersey report (Appendix D) indicate that other forms of failure governed so it was concluded that the shear capacity of the web-chord joint will not govern in shear design of the Wood I joists.

ASTM D 5055 requires that the shear capacity be determined by Equation 4 in section 6.2.12.4 of the Standard. Equation 4 is given below:

$$Ps = C (Pe - KVcPe)/2.37$$

where Ps = shear capacity in pounds (kN)

C = the product of special use reduction factors from Appendix X6 of ASTM Standard D5055

= 0.85 (this was chosen by Warnock Hersey to allow for wetting of the joists by rain during construction).

Pe = mean failure load from tests

K = factor for one-sided 95% Tolerance Limit with 5% confidence for a normal distribution.

= 1.977 (from Appendix X4 of ASTM Standard D5055) for NJ10

= 1.991 for NJ12

= 1.991 for NJS12

Vc = coefficient of variation of test data

= 0.1372 for NJ10

= 0.0393 for NJ12

= 0.0921 for NJS12

The divisor of 2.37 was developed as a combination of reduction factors and a safety factor and is very well explained in Appendix X6 of ASTM D 5055.

Table 6.3.2 outlines the shear capacities of the NJ10, NJ12, and NJS12 Wood I joists developed from the above equation and the standard beam equation for a single concentrated load applied at mid span (V = Ps/2).

Table 6.3.2 - Shear Capacities

Joist	Pe		Maximum Shear Capacity	
	lbs.	kN	lbs.	kN
NJ10	8257	36.73	1079	4.80
NJ12	8616	38.33	1424	6.33
NJS12	8617	38.33	1264	5.62

Analysis of the test results and failure modes indicated that the web-to-web joint can have a critical effect on the shear capacity. Therefore, Nascor Incorporated will be

revising its method of connecting webs-to-webs and adopting stricter quality controls for tight joints to ensure that shear transfer through the web will not be adversely affected by the web-to-web joint discontinuity.

A study of the effect of the 2 1/8" (54 mm) diameter hole in the web near a support showed that there was little or no effect except in one case; sample 16 of the NJ10 tests. Statistically speaking, it could be expected that at least one test would have a much lower failure load than the others. This low value was included in the calculation of the sample mean so its statistical relevance has been taken into account.

6.4 Allowable Bearing Capacity

At the conclusion of the structural testing of the Nascor Wood I joists, a closer look was taken at the results. It was determined that the tests that were done to establish the allowable bearing capacities of joists without web stiffeners did not truly reflect field conditions of bearing. In fact, the tests established only the crushing resistance of the OSB webs. Weyerhaeuser has previously done testing of this nature and published the allowable compressive resistance as 850 psi (5.86 MPa) for their Struc One, Web Stock OSB. Although the crushing resistance of the web is one of the major bearing concerns, there are

two other critical concerns that were not covered by the testing. These are the allowable compression perpendicular to grain for the bearing portion of the bottom chord and the allowable vertical load capacity of the web bearing in the slot of the chords (ie - punch - through of the web through the chord). All three concerns are based on the bearing length of the joists and, again, the tests that were done did not investigate the effect of bearing length.

Therefore Nascor will establish the bearing capacity of each joist by theoretical means until more meaningful tests can be run.

The tests done to establish bearing capacity with web stiffeners attached, again proved very little. The web stiffeners used in the test were 5/8" (15.9 mm) thick OSB, however, only 2x4 (38x89 mm) or 2x6 (38 x 140 mm) web stiffeners will be used in the field. For joist design purposes, the bearing capacity of a joist with one or two web stiffeners at a support will be theoretically calculated as the lower value of any of the applicable three concerns mentioned above or the allowable compression perpendicular to grain of the area of web stiffener bearing on the top face of the bottom chord.

6.5 Creep Test Performance

Although ASTM D 5055 covers test procedures for performing creep tests, CCMC has developed requirements which are slightly different from those in the ASTM standard. Since Nascor expects to have CCMC evaluate the Nascor Wood I joists, it was decided to perform the creep tests in accordance with the CCMC requirements (see Appendix A for CCMC requirements).

The intent of the creep tests was to discover how the joist assemblies would perform under load over increments of time and loads.

The tests were divided into 7 steps of load and time increments as outlined in Section 5.4 of this report.
The first determinant in the test procedure was whether the deflection of the joist assemblies would exceed a deflection limit of span/360 under a 10psf (0.5 kN/m2) uniform load. The next determinant was whether, under a 42 psf (2.0 kN/m2) load, there was any further deflection after 24 hours from what there was after one hour (any additional deflection was not allowed to exceed 25% of the deflection that occurred after one hour). The last determinant of the testing was whether the difference in deflection between step 3 and step 6 was within a

deflection of span/440.

In all cases, the Nascor Wood I joists met the requirements above and thus met the creep performance requirements of CCMC.

6.6 Summary of Structural Capacities

Tables 6.6(a) and (b) summarize the structural capacities of the NJ10, NJ12, and NJS12 Wood I floor joists.

Table 6.6(a) - Summary of Structural Capacities (Imperial Values)

JOIST	MOMENT CAPACITY (lbs. - ft.)	SHEAR CAPACITY* (lbs.)	STIFFNESS VALUE(EI) (lbs. - $in.^2$)
NJ10	2681	1079	169×10^6
NJ12	5524	1424	291×10^6
NJS12	5529	1264	308×10^6

Table 6.6(b) - Summary of Structural Capacities (Metric Values)

JOIST	MOMENT CAPACITY (N-m)	SHEAR CAPACITY* N	STIFFNESS VALUE(EI) ($N\text{-}mm^2$)
NJ10	3635	4800	485×10^9
NJ12	7490	6334	835×10^9
NJS12	7496	5623	884×10^9

* The shear capacity is the lesser of the web-to-chord allowable shear or the allowable shear of the web and web-to-web joints. In all cases the latter governed.

6.7 Comparison of Allowable Spans of Nascor Joists to Conventional Wood Joists.

Table 6.7(a) and (b) below summarize the allowable spans of Nascor Wood I floor joists and conventional wood floor joists. The allowable spans for conventional wood floor joists are taken from Table A2 of the 1985 and 1990 editions of the National Building Code of Canada.
Table 6.7(a) and (b) are based on a live load of 40 psf

(1.9 kPa) and a dead load of 10 psf (0.48 kPa) and No. 1 grade lumber for the conventional wood joists. A deflection limit of span/360 was used for the Nascor joists. The joists are all assumed to be bridged and strapped.

Table 6.7(a) - Allowable Span Comparison (Imperial Values)

YEAR		NASCOR JOISTS			CONVENTIONAL WOOD JOISTS			
	SPACING				S-P-F-#1		D.FIR #1	
OF CODE	in.	NJ10	NJ12	NJS12	2X10	2X12	2X10	2X12
(85)	12"	18'-4"	21'-11"	22'-4"	17'-2"	20'-11"	18'-11"	23'-0"
	16"	16'-8"	19'-11"	20'-4"	15'-7"	18'-11"	17'-2"	20'-10"
	24"	14'-6"	17'-4"	17'-9"	13'-4"	16'-2"	15'-0"	18'-3"
(90)	12"	18'-4"	21'-11"	22'-4"	15'-1"	17`-0"	15'-11"	17'-10"
	16"	16'-7"	19'-11"	20'-4"	14'-1"	15'-10"	14'-9"	16'-7"
	24"	14'-6"	17'-4"	17'-9"	13'-2"	14'-9"	13'-9"	15'-6"

Table 6.7(b) - Allowable Spans (Metric Values)

YEAR OF CODE	SPACING (mm)	NASCOR JOISTS			CONVENTIONAL WOOD JOISTS			
					S-P-F #1		D/FIR #1	
		NJ10	NJ12	NJS12	38x235	38x286	38x235	38x286
(85)	300	5.59	6.68	6.81	5.23	6.36	5.76	7.00
	400	5.08	6.07	6.20	4.75	5.78	5.23	6.36
	600	4.42	5.28	5.41	4.06	4.93	4.57	5.56
(90)	300	5.59	6.68	6.81	4.60	5.17	4.84	5.43
	400	5.08	6.07	6.20	4.29	4.82	4.51	5.06
	600	4.42	5.28	5.41	4.00	4.49	4.20	4.72

7.0 ECONOMIC IMPACT

Most builders have already been convinced that the Wood I floor joist is a superior construction material but have been hesitant to incorporate them into their projects mainly due to price considerations.

The introduction of the Nascor Wood I joists to the residential construction market is expected to have considerable impact on builders. Previously, builders had only two or three companies in Canada from whom to purchase Wood I floor joists. With the competitive pricing of the Nascor Wood I floor joists, builders now have a wider range of products with a wider range in pricing from which to choose.

Shown below is a contractor price comparison between the Nascor Wood I joists and conventional wood joists:

NJ10	-	$1.07 PER LINEAL FOOT
NJ12	-	$1.17 PER LINEAL FOOT
NJS12	-	$1.30 PER LINEAL FOOT
2 X 10 D. FIR #1	-	$0.75 PER LINEAL FOOT
2 X 12 D. FIR #1	-	$1.03 PER LINEAL FOOT

The above Nascor prices are tax out and F.O.B. plant. The prices for the conventional wood joists are tax out and are

an average of the prices in the City of Calgary as of February, 1991 (it should be noted that the prices for conventional wood joists were quite low at the time of this writing (due to a construction slump) and would normally be 10% to 15% higher).

8.0 CONCLUSION

Market research in the residential construction industry by Nascor Incorporated indicated that builders are becoming increasingly receptive to incorporating Wood I floor joists into their floor systems. Decreasing quality of conventional floor joists, increasing costs of conventional floor joists, and recently, the decreased allowable spans contained in the 1990 National Building Code of Canada have all contributed to their increased interest in Wood I floor joists.

To date, the main reasons why builders are not using the structurally superior Wood I floor joist in more of their projects are cost and incompatibility with conventional construction practices. This defined the objectives for the development of the Nascor NJ10, NJ12, and NJS12 Wood I floor joists. The Nascor joists are less costly than other Wood I joists on the market and have been dimensioned to be compatible with conventional construction hardware (such as joist hangers).

From structural testing of the NJ10, NJ12, and NJS12 joists, the following properties and conclusions were established:

i) Bending Moment Capacity

NJ10 3635 N-m (2681 lb-ft)

NJ12 7490 N-m (5524 lb-ft)

NJS12 7496 N-m (5529 lb-ft)

ii) Shear Capacity

NJ10 4800 N (1079 lbs)

NJ12 6334 N (1424 lbs)

NJS12 5623 N (1264 lbs)

iii) Stiffness Coefficient (EI Value)

NJ10 485 x 10^9 N-mm (169x10^6 lbs-in^2)

NJ12 835 x 10^9 N-mm (291x10^6 lbs-in^2)

NJS12 884 x 10^9 N-mm (308x10^6 lbs-in^2)

iv) The creep performance of all three joists met CCMC's requirements.

The joists all performed as expected and structural capacities compared closely to those determined by theoretical analysis.

The structural tests also revealed some weaknesses in the design of the web-to-web joints of the Wood I joists. This joint (currently a tongue and groove connection, will be redesigned for higher shear capacities. Bearing capacity tests were inconclusive since only one form of bearing failure was investigated by the particular test that was

done and this test did not represent field bearing conditions very closely. More representative tests are planned for the near future.

The test program confirmed the structural merit of the joists and satisfied the requirements for a CCMC Product Listing application. The results of the testing along with other supporting documents have now been submitted to CCMC for evaluation.

APPENDIX A CCMC's "Technical Guide for Prefabricated, Structural Wood Beams and Joists"

National Research Council Canada
Conseil national de recherches Canada

Institute for Research in Construction
Institut de recherche en construction

Ottawa, Canada
K1A 0R6

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16 May 1990

Nascor Inc.
7803P-35th Street S.E.
Calgary, Alberta
T2C 1V3

Att: Mr. Blair Nutting

Dear Mr. Nutting:

Re: CCMC Guide for Structural Wood Joists

As you requested, enclosed is a copy of CCMC's technical guide for "Prefabricated, Structural Wood Beams and Joists", dated 90-01-15.

Yours truly,

R.C.Waters
Evaluation Officer
Canadian Construction Materials Centre

Canada
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Canadian Construction Materials Centre

Technical Guide for

Prefabricated, Structural Wood Beams and Joists

Masterformat Section: ***06195***

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Evaluation to this guide is on a fee-for-service basis and is valid for three (3) years.

Date: 90-01-15

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1.0 Scope

This Technical Guide describes the criteria for the assessment of floor framing systems in which the framing members consist of two or more pieces assembled to form a floor truss. It does not apply to conventional wood floor joists for which span tables are included in the National Building Code of Canada, 1985. But it does apply to prefabricated I-joists made of wood.

It has been prepared by the staff of the Canadian Construction Materials Centre. The determination of the criteria is the result of the following functions:

- reference and review of the former technical requirements (by CMHC) for floor trusses;
- review and adoption of CMHC's ME 8309 standard (Load Test Procedure for Floor Framing Systems for Houses and Small Buildings); and
- review of CMHC evaluation reports for similar products.

2.0 Definitions

Recognized laboratory - a laboratory from which CCMC will accept test results

Applicant - the manufacturer of a product or the sole Canadian distributor of the product

Prefabricated wood I-joist - a structural member - I-shaped in cross-section - manufactured from sawn or structural composite lumber flanges and structural panel webs, bonded together with exterior exposure adhesives

3.0 Applicable Codes and Standards

3.1 National Building Code of Canada (NBC), 1985

3.2 Canadian Standards Association (CSA)

- CSA S347-M1980 Method of Test for Evaluation of Truss Plates Used in Lumber Joists
- CSA 086-M84 Engineering Design in Wood

3.3 Where the Code and Standards May be Purchased

NBC National Research Council of Canada
Montreal Road
Ottawa, Ontario
K1A 0R6

CSA Canadian Standards Association
178 Rexdale Boulevard
Rexdale, Ontario
M9W 1R3

4.0 General Evaluation Procedures

In evaluating the submitted product, the CCMC evaluation officer verifies that the product and its test results comply with the requirements outlined in this Technical Guide. The test results will be taken into account when determining the uses and limitations of the product.

5.0 Technical Requirements

Floor and roof joists shall be designed in accordance with the requirements of CAN3-086-M84 (Engineering Design in Wood).

The drawings and related documents shall bear the authorized professional seal and signature of a professional engineer or architect skilled in wood design and licensed to practise under the appropriate provincial or territorial legislation. The drawings shall show the applicable design loads and deflections.

5.1 Criteria for Acceptable Performance

When tested in accordance with Section 6 in this Technical Guide, the wood beams and joists must meet the following criteria for acceptable performance:

- The maximum difference in the deflections measured in Step 3 of Subsection 6.2.8 and those measured in Step 4 **shall not exceed 1/360 of the span or 13 mm**, whichever is smaller.

- **The difference in deflection at any one point**, as measured in Step 4 of Subsection 6.2.8, **shall not exceed 25 per cent of that measured in Step 3.**

- The maximum difference in the deflections measured in Step 3 of Subsection 6.2.8 and that measured in Step 5 of Subsection 6.2.8 shall not exceed 1/1440 of the span.

- The system shall survive the load exerted in Step 6 of Subsection 6.2.8 without collapse.

5.2 Acceptable Performance

If the results of all **three required tests** successfully meet the criteria in Section 5.1, the design is considered acceptable.

If the results of one of the tests do not meet the criteria, one retest is permitted.

If the results of the retest or of two of the original tests do not meet the criteria, the design is considered unacceptable.

6.0 Testing

6.1 Sampling

Applicants must contact CCMC to arrange a random selection, by a CCMC regional inspection representative, of production line samples for their identification before they are sent to the testing laboratory.

The framing members to be tested shall be representative of those made in regular production. They shall be fabricated from the same type of material by the same methods and with the same equipment.

For wood systems, the lumber used shall be grade-marked, except for short pieces from which the removal of the grade mark during fabrication is unavoidable. Such pieces shall, however, meet the intent of the appropriate grading rule. The lumber shall neither be stronger nor stiffer than the strength groups and grades used in regular production. Lumber is considered representative, if its relative density is within the range of the CSA S347-M1980 standard for the species group specified (see Table 1).

Where a maximum moisture content is not specified for the production of wood systems, the framing members shall be assumed to be manufactured from unseasoned lumber, and the test specimens shall be fabricated from lumber with a moisture content in excess of 30 percent. Where a maximum moisture content is specified, the test specimens shall be fabricated from lumber having a moisture content within 3 per cent of the specified level. Moisture content at the time of testing shall not exceed 19 per cent.

Both the depth of the beam and the spans to be tested are critical factors, therefore their advance acceptance by CCMC is required. The manufacturer should make prior arrangements with the testing agency and CCMC for the witnesssing of sampling.

Applicants should contact the testing organization to obtain information regarding fees and samples required for testing.

6.2 Testing Procedures

6.2.1 Supervision of Testing

A professional engineer licensed to practise in Canada under provincial or territorial legislation must supervise the testing.

6.2.2 Establishing the Validity of Designs of Wood Assemblies

It is important in testing wood assemblies to establish the validity of designs, so that the lumber used is representative of the species group and grade specified. Since strength and stiffness of lumber are related to its density, some control of the density of lumber can ensure that the lumber is representative. Hence, lumber whose density falls within the range shown in Table 1 for the appropriate species group can be considered representative.

Table 1
Allowable Basic Relative Density Ranges for Truss Plate Tests

Species Group	Species To Be Used for Test Specimen	Allowable Basic Relative Density Range
D. Fir-L	Douglas Fir	0.39 - 0.46
Hem Fir	Amabilis Fir	0.31 - 0.37
Hem Tam	Eastern Hemlock	0.36 - 0.41
S-P-F	Spruce (any species)	0.31 - 0.36
North Species	White Pine	0.31 - 0.37

6.2.3 Number of Trusses Tested

Three individual or three pairs of full-scale trusses shall be tested to evaluate a design. Supports and bracing shall simulate, but not exceed, those called for in the design drawings.

6.2.4 Tests of Single Trusses

The top chord may be prevented from buckling by lateral restraints, provided these supports neither restrain vertical deflection of the truss in any way nor assist in carrying any applied load.

6.2.5 Tests of Pairs of Trusses

Lateral stability during testing shall be ensured by spacing the trusses at least 600 mm apart, even if they are designed to be more closely spaced in actual use. The top chords shall be sheathed with plywood, or they may be prevented from buckling by lateral restraints, provided these supports neither restrain vertical deflection of the truss in any way nor assist in carrying any applied load. The length or width of the plywood sheets shall not exceed 1200 mm, and the thickness of a sheet shall be at least 18.5 mm. Plywood sheets are to be placed with the face grain at right angles to the top chords. The sheathing shall be nailed to the top chords with 51-mm common nails at 150-mm spacing, with a gap of at least 2 mm left between sheets. The top of the bottom chords may be sheathed with plywood like the top chords; or alternatively, boards or slats applied at right angles to the bottom chord may at least be used at the quarter points of the panel.

6.2.6 Deflection Measurements

Unless otherwise approved, deflection shall be measured at the mid-span and other likely points of maximum deflection, and at all splices and joints along the surface of the member (upper or lower) closest to the one on which the supports are located.

Deflections shall be measured by reading the movement of graduated scales fastened to the member at points where deflection measures are required. The movement is measured relative to a taut wire or other line, not greater than 0.5 mm in diameter, fastened to the member at the supports. The scales shall have graduations of 1 mm or finer. The scales and wire shall be fastened at or near that surface of the member (upper or lower) closest to the one on which the supports are located. The wire shall be kept taut by springs or counterweights. Parallax errors shall be avoided either by using small mirrors fastened to the member behind the wire or by using two parallel wires. Where the member is continuous over two or more spans, each span shall be instrumented separately. Deflection measurements shall be recorded to the nearest 0.5 mm.

Other methods for measuring deflections may be used if approved by CCMC.

6.2.7 Loads for Testing

Loads may be applied by means of weights, hydraulic jacks, or other suitable apparatus.

Table 2
Test Loads

Test Load	Weight (kN/m^2)	Parameter Simulated by the Test Load
(a)	0.5	Dead weight of finished floor and ceiling
(b)	0.5	Weight of non-loadbearing partitions where the span of the members exceeds 5 m
(c)	2.0	Design live load

The method of measuring the loads shall be accurate to ±5 per cent.

When weights are used, they shall be distributed uniformly along the truss and sufficient space left between them to avoid arching. If concrete blocks or other rigid weights are used, their length in the direction parallel to the truss shall not exceed 400 mm.

Caution: When loads are applied by means of weights, use safety supports to prevent injury through the complete collapse or overturning of the trusses.

The safety supports must be clear of the trusses during testing. Their height should be adjustable so that they can be maintained within 50 mm of the members they are to catch in case of collapse or overturning.

6.2.8 Test Procedure

Step	Task
1	Measure the moisture content of wood members at a sufficient number of points to give a representative picture of the overall moisture condition of the members.
2	Take zero deflection readings before applying any load.
3	Apply test load (a) at a steady rate and take deflection readings at the following times:

Test Load	Weight (kN/m^2)	Time of Deflection Readings (s)
(a)	0.5	300
(b)	0.5	300
(c)	2.0	3600*

* For members continuous over two or more spans, test load (c) shall be placed on one span only.

Take a photograph of the assembly.

4	For wood systems, maintain these loads for an additional 23 hours and take deflection readings again.
5	Remove test load (c) and take deflection readings 300s after its complete removal.

Take a photograph of the assembly.

Step	Task
6	Increase the load on the members to a level equal to twice the total of all loads described in Table 2, i.e., 6 kN/m^2. For non-wood systems, this load shall be maintained for 1 hour; for wood systems, for 24 hours. Take a photograph of the assemblies. **Note:** For members continuous over two or more spans, this overload shall be applied to each span, one span at a time while maintaining test loads (a) and (b) on the other spans, and then to all spans at the same time. For non-wood systems, maintain each complete loading cycle for 1 hour; for wood systems, for 24 hours.
7	For wood systems, take sufficient samples from the members for measuring relative density to give a representative measure of the overall density of the lumber used in the members.

6.2.9 Report Submitted by Testing Authority

The report submitted by the testing authority shall include:

- detailed drawings of the assembly tested, showing overall dimensions, member sizes, material specifications, joint details and locations, and other relevant information;
- photographs taken of the assembly at Steps 3, 5, and 6 in Section 6.2.8;
- a brief description of the fabrication method employed;
- details of moisture content measurements at the time of fabrication and at the time of testing, and a brief description of the method used to measure moisture content;
- details of relative density measurements and a brief description of the method used to determine relative density;
- the test loads applied, all deflection measurements, and the calculations of deflection differences with the same numerical designations used in this Technical Guide;
- a description of the method of applying load; and

- a statement whether the acceptable performance criteria were met and whether a retest was required.

6.3 Testing Organizations

Testing must be conducted at a facility recognized by CCMC. Test reports from the following facilities are currently acceptable to CCMC:

- Forintek Canada Corporation
- Alberta Research Council
- Ortech International
- University of Toronto
- Warnock Hersey International Ltd. (B.C.)

The addresses and contact persons for these laboratories are noted in the attached list of CCMC Regional Laboratory Support Networks. All samples sent to the laboratories or to CCMC must be identified by a label as called for in Section 6.1.

Applicants must cover the costs of testing and authorize the testing agency to forward the original test report for all samples to CCMC. The test reports become the property of CCMC.

7.0 Quality Assurance Program

7.1 General Requirements

Applicants must provide evidence that the manufacturing process is controlled so as to provide consistent quality at least to the level represented by the sample tested and evaluated. Quality control procedures must apply to incoming materials, processes, and finished products. Evidence of quality assurance may be certification that the facility is under the control of a registered quality assurance agency, or a copy of a quality control manual (QCM).

7.2 Quality Control Manual

7.2.1 Purpose

The purpose of the QCM is to have guidelines for the control of quality of the manufacturing process, so that the sample submitted is representative of the products manufactured at the plant. It remains the manufacturer's responsibility to ascertain that manufactured products meet or exceed the quality of the sample submitted for testing.

The QCM will be reviewed by an evaluation officer prior to issuing an evaluation number. Other documents judged necessary at the time of application to complete the QCM shall be submitted by the applicant as requested.

7.2.2 Conditions

The QCM must be prepared by the manufacturer or by a third party recognized by CCMC and signed by an authorized officer, designated by the applicant, to confer legitimacy onto the document.

The QCM must have provisions to permit representatives of CCMC or its authorized agents to enter the specified premises, without prior notice, for the purpose of inspecting the manufacturing facilities or designating samples for testing.

7.2.3 Content

The QCM shall contain the following information:

- the company's quality control policies;
- organizational charts, resumes of key personnel and responsibilities pertinent to the quality control function;
- provisions for keeping the manual current, e.g., updates and revisions;
- name, address, and telephone number of the manufacturing facility and individuals responsible for supervision of quality control;
- a production flow chart indicating points of quality control, complete with an explanation of the control at each point, frequency of controls, and resume of the production methods;
- production specifications, assembly drawings, and manufacturing tolerances;
- a clear delineation of major and minor defects;
- corrective measures for major and minor defects;
- a list of major production equipment;
- a list of the manufacturer's specifications and quality control arrangements for raw materials, manufactured components, and sub-assemblies;
- measuring equipment: type, model, range, accuracy, and calibration; and
- a statement by the manufacturer that CCMC will be notified, in writing, when major deviations have been discovered.

8.0 Installation Manual (Including Design)

8.1 Purpose

The manufacturer shall provide a well defined and detailed installation manual as reference for designers, installers, and users of the product.

8.2 Content

The manual shall contain the following information:

- quality control and identification of evaluated products;
- a list of the engineering properties of the joists;
- a statement that all joists shall be designed in accordance with the requirements of CAN3-086-M84 (Engineering Design in Wood);
- the cutting, drilling, or notching of top or bottom chords;
- details on the composite parts of the floor joists;
- details on lateral support bridging and wet stiffeners;
- minimum end and intermediate support bearing; and
- limitations on the size and location of holes in the web section.

9.0 Submission Package

Upon successful completion of testing, applicants must submit to CCMC a typical sample of the product, approximately 300 mm long, and the following documentation:

- a completed form entitled "Application for Construction Materials Evaluation";
- confirmation that the applicant is an authorized representative of a legally constituted company;
- a detailed outline of the applicant's quality assurance program;
- a manual for the installation of the product on site;
- span tables and fabrication drawings certified by a professional engineer;
- a copy of the guarantee or warranty issued to the user of the product; and
- an original inked drawing of the product to a scale of 1:10 on mylar, Clearpring 1000H, or equivalent drawing paper. The paper size is to be 215 by 279 mm.

Note: Lack of information or samples will delay evaluation.

The application, samples, and documentation should be carefully packaged to avoid damage in transit and shipped prepaid, including clearance through Canadian Customs if applicable, to:

Canadian Construction Materials Centre
Institute for Research in Construction
National Research Council of Canada
Montreal Road, Building M-24
Ottawa, Ontario
K1A 0R6

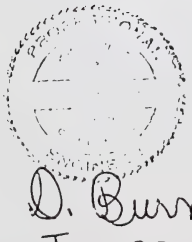
Telephone (613) 993-6312
Facsimile (613) 952-0268

APPENDIX B Allowable Load Tables For NASCOR Wood I Floor Joists

STRENGTH TABLE

(LF) CLEAR SPAN	NASCOR JOIST ALLOWABLE UNIFORM LOADS (LBS PER LINEAL FEET)	
	NJ10	NJ12
4	540	598
5	432	478
6	360	398
7	308	341
8	270	299
9	240	266
10	214	239
11	177	217
12	149	199
13	127	184
14	109	171
15	95	159
16	84	149
17	74	141
18	66	133
19	59	122
20	54	105
21	49	91
22	44	79
23	41	70
24	36	61

Jan. 28, 1991



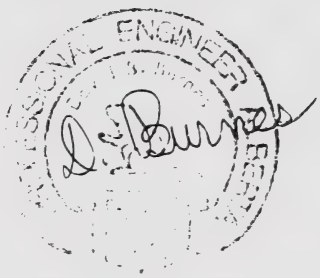
D. Burnes

Jan. 28, 1991

NOTES ON STRENGTH TABLE:

- The "STRENGTH TABLE" must be used in conjunction with the "DEFLECTION TABLES".
- Total load deflection is span/180.
- Load duration factor is 1.00. For other load conditions multiply the above values by the applicable load duration factor.

- The above table is based on uniform loads.
- The values shown in the above table are for one beam only. Double the values for two beams, triple the values for 3 beams. Refer to the Nascor Technical Manual for connection details.



Jan. 28, 1991

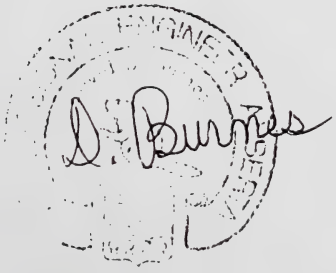
D. Burnes
Jan. 28, 1991

APPENDIX C Allowable Span Tables For NASCOR Wood I Floor Joists

NASCOR FLOOR JOIST SPAN TABLE

LOAD (PLF)	O.C. SPACING	NASCOR JOIST NJ10	NJ12	NJS12
Live 30 Dead 10	12"	20'-2"	24'-2"	24'-8"
	16"	18'-4"	21'-11"	22'-5"
	19.2"	17'-3"	20'-8"	21'-1"
	24"	16'-0"	19'-2"	19'-6"
Live 30 Dead 15	12"	20'-2"	24'-2"	24'-8"
	16"	18'-4"	21'-11"	22'-5"
	19.2"	17'-3"	20'-8"	21'-1"
	24"	16'-0"	19'-2"	19'-6"
Live 40 Dead 10	12"	18'-4"	21'-11"	22'-4"
	16"	16'-8"	19'-11"	20'-4"
	19.2"	15'-8"	18'-9"	19'-1"
	24"	14'-6"	17'-4"	17'-9"
Live 40 Dead 15	12"	18'-4"	21'-11"	22'-4"
	16"	16'-8"	19'-11"	20'-4"
	19.2"	15'-8"	18'-9"	19'-1"
	24"	14'-0"	17'-4"	17'-9"

REFER TO PAGE 5 FOR NOTES.



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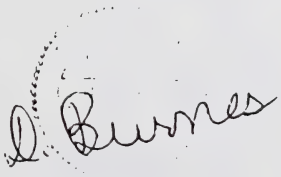

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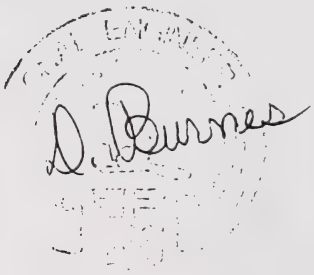
NASCOR FLOOR JOIST SPAN TABLE (continue)

LOAD (PLF)	O.C. SPACING	NASCOR JOIST NJ10	NJ12	NJS12
Live 40 Dead 20	12"	18'-4"	21'-11"	22'-5"
	16"	16'-4"	19'-11"	20'-4"
	19.2"	14'-11"	18'-9"	19'-1"
	24"	13'-4"	17'-4"	17'-9"
Live 40 Dead 25	12"			
	16"			
	19.2"			
	24"			
Live 40 Dead 30	12"			
	16"			
	19.2"			
	24"			
Live 50 Dead 10	12"	17'-0"	20'-4"	20'-9"
	16"	15'-5"	18'-6"	18'-10"
	19.2"	14'-6"	17'-4"	17'-9"
	24"	13'-4"	16'-1"	16'-5"

REFER TO PAGE 5 FOR NOTES.



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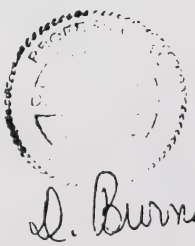

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NASCOR FLOOR JOIST SPAN TABLE (continue)

LOAD (PLF)	O.C. SPACING	NASCOR JOIST NJ10	NJ12	NJS12
Live 50 Dead 15	12"	17'-0"	20'-4"	20'-9"
	16"	15'-5"	18'-6"	18'-10"
	19.2"	14'-4"	17'-4"	17'-9"
	24"	12'-10"	16'-1"	16'-5"
Live 50 Dead 20	12"	17'-0"	20'-4"	20'-9"
	16"	15'-2"	18'-6"	18'-10"
	19.2"	13'-10"	17'-4"	17'-9"
	24"	12'-5"	16'-1"	16'-5"
Live 50 Dead 25	12"			
	16"			
	19.2"			
	24"			
Live 50 Dead 30	12"			
	16"			
	19.2"			
	24"			

REFER TO PAGE 5 FOR NOTES.

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NASCOR FLOOR JOIST SPAN TABLE (continue)

NOTES ON SPAN CHARTS:
The span charts are based on:

- Live load deflection limit is span/360.
- Total load deflection limit is span/180.
- Load duration factor is 1.00
- A minimum of 1-1/2" bearing must be provided.
- Spans are the clear distance between supports.
- Only uniform loads are applied.
- 5/8" T&G plywood nailed to joists.
- Use the "STRENGTH TABLE" and "DEFLECTION TABLES" to design the live load and dead load combinations which are not covered by "SPAN CHARTS".
- Refer to the "NASCOR TECHNICAL MANUAL" for stiffener requirement, bridging, bearing capacities and connection details.

The span can be increased if:
- Subfloor is glued, increase span by 10 percent.
- 3/4" plywood is nailed to joists, increase span by 6 percent.

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APPENDIX D Warnock Hersey Structural Test Reports

Warnock Hersey

WARNOCK HERSEY PROFESSIONAL SERVICES LTD.
211 SCHOOLHOUSE ST., COQUITLAM, BRITISH COLUMBIA
CANADA V3K 4X9 PHONE (604) 520-1321
TELEX 04-352076 WHSM VCR TELEFAX (604) 521-0186

February 4, 1991

Nascor Incorporated
7803P - 35th Street
S.E. Calgary, Alberta
T2C 1V3

Attention: Mr. Sao Hoang

Dear Sir,

Re: Test Results for Nascor Wood I Beams

We have completed physical testing on your Wood Joists in accordance with ASTM Standard D 5055-90, "Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood Joists".

The summary of capacities listed below for the Nascor Wood Joists is based on test data listed in reports previously issued to Nascor Inc. The report numbers and dates are listed along with the individual wood joist capacities. Copies of each report are enclosed.

The Bending Moment capacities are based on the lowest test values divided by a safety factor of 2 - 1. The EI or Stiffness values were obtained using both bending and shear deflection formulae. The NJU16 EI capacity has also been corrected for testing on 14 to 1 span to depth ratio as opposed to a 18 to 1 span to depth ratio as recommended by the ASTM test standard.

The Shear capacity values given were calculated using the Shear Capacity formula given in ASTM D5055-90. Detailed calculations for each joist size are enclosed.

The Web to Chord and Bearing capacity values were obtained using the lowest test value obtained divided by a safety factor of 2.1. The Bearing capacity is calculated by dividing the test load by the bearing area in square inches.

1. Nascor NJ10 Report No. 7/90 Dated August 31/90

a)	Bending Moment Capacity	2,681 ft. x lbs.
b)	Shear Capacity (Max. Reaction)	1,079 lbs.
c)	Web to Chord Joint	126 psi
d)	Bearing Capacity	
	i) without stiffener	225 psi
	ii) with 5/8" OSB one side	230 psi
	iii) with 5/8" OSB both sides	283 psi
e)	Stiffness (EI Constant)	169.0 x 10^6 lbs. x $in.^2$

.../2

VANCOUVER REGINA WINNIPEG SAULT STE MARIE HAMILTON TORONTO MONTREAL HALIFAX ANTIOCH LONG BEACH MADISON BALTIMORE
RECEIVED

2. Nascor NJ12 Report No. 5/90 Dated August 30/90

a)	Bending Moment Capacity	5,524 ft. x lbs.
b)	Shear Capacity (Max. Reaction)	1,424 lbs.
c)	Web to Chord Joint	126 psi
d)	Bearing Capacity	
	i) without stiffener	174 psi
	ii) with 5/8" OSB one side	221 psi
	iii) with 5/8" OSB both sides	271 psi
e)	Stiffness (EI Constant)	291.0 x 10^6 lbs. x $in.^2$

3. Nascor NJS12 Report No. 8/90 Dated August 31/90

a)	Bending Moment Capacity	5,529 ft. x lbs.
b)	Shear Capacity (Max. Reaction)	1,264 lbs.
c)	Web to Chord Joint	126 psi
d)	Bearing Capacity	
	i) without stiffener	200 psi
	ii) with 5/8" OSB one side	245 psi
	iii) with 5/8" OSB both sides	310 psi
e)	Stiffness (EI Constant)	308.0 x 10^6 lbs. x $in.^2$

If you have any questions, please contact us.

Yours truly,

WARNOCK HERSEY PROFESSIONAL SERVICES LTD.

Farid Mawani, P.Eng.
Manager, Field Services
Physical Testing Division

FM/cr

EI CALCULATIONS

EI VALUES

Warnock Hersey conducted the bend testing to establish the EI values. The load was applied at the third points of the joist. Warnock Hersey used the deflection formula to establish the EI values as follows:

$$def = \frac{(23*p*1^3)}{(648*EI)} \qquad (a)$$

The above formula assumes that only bending is effectting the deflection. According to the ASTM standard the shear deflection should also be taken into account.

$$def = \underbrace{\frac{23*p*1^3}{648*EI}}_{\text{(bending)}} + \underbrace{\frac{Ew*c*h^2*1*P*1}{GwXEI}}_{\text{(shear)}} \qquad (b)$$

Here are the new EI values based on formula (b):

NJ10

From the test data, the average p/def slope was obtained by Linear Regression.

$$p/def = 940.97 \text{ lbs/in}$$

Apply the above p/def to formula (b):

Rearrange formula (b):

$$EI = \left(\frac{23*1^3}{648} + \frac{Ew*c*h^2*k*1}{Gw}\right)\frac{P}{def}$$

Where

1	=	171"	tested span
Ew	=	$0.65*10^6$ psi	MOE of web
c	=	0.166	two point load factor (from section 7.6.3.3 CSA 086-M84)
h	=	9.5"	joist depth
k	=	0.27	section shear constant (from section 7.6.3.3 CSA 086-M84)
Gw	=	$0.19*10^6$ psi	web shear modulus

EI VALUES: (continued)

Therefore,

$$EI = 167*10^6 + \left(\frac{0.65*10^6*0.166*9.5^2*0.27*171}{0.19*10^6}\right)*940.97$$

$$= 167*10^6 + 2.23*10^6$$

$$= 169.23*10^6 \text{ lbs-in}^2$$

NJ12

From the test data, the average p/def slope was obtained by Linear Regression.

$$p/def = 835.86 \text{ lbs/in}$$

Apply the above p/def to formular (b):
Rearrange formular (b):

$$EI = \left(\frac{23*1^3}{648} + \frac{Ew*c*h^2*k*1}{Gw}\right)\frac{P}{def}$$

Where

1	=	213"	tested span
Ew	=	$0.65*10^6$ psi	MOE of web
c	=	0.166	two point load factor (from section 7.6.3.3 CSA 086-M84)
h	=	11.875"	joist depth
k	=	0.27	section shear constant (from section 7.6.3.3 CSA 086-M84)
Gw	=	$0.19*10^6$ psi	web shear modulus

Therefore,

$$EI = 286.7*10^6 + \left(\frac{0.65*10^6*0.166*11.875^2*0.27*213}{0.19*10^6}\right)*835.86$$

$$= 286.7*10^6 + 3.85*10^6$$

$$= 290.55*10^6 \text{ lbs-in}^2$$

EI VALUES: (continued)

NJS12

From the test data, the average p/def slope was obtained by Linear Regression.

p/def = 884.84 lbs/in

Apply the above p/def to formula (b):
Rearrange formula (b):

$$EI = \left(\frac{23*1^3}{648} + \frac{Ew*c*h^2*k*1}{Gw}\right)\frac{P}{def}$$

Where

1	=	213"	tested span
Ew	=	$0.65*10^6$ psi	MOE of web
c	=	0.166	two point load factor (from section 7.6.3.3 CSA 086-M84)
h	=	11.875"	joist depth
k	=	0.27	section shear constant (from section 7.6.3.3 CSA 086-M84)
Gw	=	$0.19*10^6$ psi	web shear modulus

Therefore,

$$EI = 303.5*10^6 + \left(\frac{0.65*10^6*0.166*11.875^2*0.27*213}{0.19*10^6}\right)*884.84$$

$$= 303.5*10^6 + 4.08*10^6$$

$$= 307.58*10^6 \text{ lbs-in}^2$$

SHEAR CAPACITY CALCULATIONS

NASCOR INC. NJ10 WOOD JOIST WITH 2 X 3 CHORDS

SHEAR CAPACITY CALCULATIONS

SHEAR CAPACITY AS PER ASTM D5055 - 90

P	=	8257 lbs (average)
S	=	1133 lbs (standard deviation)
V	=	0.1372 (S/P)
K	=	1.977 from table X4.3 for 16 smaples
C	=	0.850 for load duration
Ps	=	C[P - (KvP)]/2.37
	=	2158 lbs
V max	=	1079 lbs

NASCOR INC. NJ12 WOOD JOIST

SHEAR CAPACITY CALCULATIONS

SHEAR CAPACITY AS PER ASTM D5055 - 90

P	=	8616 lbs (average)
S	=	339 lbs (standard deviation)
V	=	0.0393 (S/P)
K	=	1.991 from table X4.3 for 15 smaples
C	=	2.85 for load duration
Ps	=	C[P - (KvP)]/2.37
	=	2848 lbs
V max	=	1424 lbs

NASCOR INC. NJS12 WOOD JOIST

SHEAR CAPACITY CALCULATIONS

SHEAR CAPACITY AS PER ASTM D5055 - 90

P	=	8617 lbs (average)
S	=	794 lbs (standard deviation)
V	=	0.0921 (S/P)
K	=	1.991 from table X4.3 for 15 smaples
C	=	0.85 for load duration

Ps	=	C[P - (KvP)]/2.37
	=	2528 lbs
V max	=	1264 lbs

Warnock Hersey Professional Services Ltd.
211 Schoolhouse St., Coquitlam, B.C. V3K 4X9 - (604) 520-3321 - Telecopier (604) 524-9186

REPORT OF: Physical Tests on Wood Joists

AT: Coquitlam Laboratory

DATE: Aug. 31/90

PROJECT: 50484 C7 719500

REPORT NO: 7/90 Rev.

REPORTED TO: Nascor Incorporated
7803P - 35 Street S.E.
Calgary, Alberta
T2C 1V3

ORDER NO.

Revised: February 1, 1991
Attention: Soa Hoang

NJ10 -ASTM

INTRODUCTION

As requested, we have conducted Physical Tests on samples of Wood Joists submitted to our laboratory by Nascor Inc. The submitted Wood Joists were tested in accordance with the proposed American Society of Testing and Materials (ASTM) Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists.

The submitted Wood I-Joists were identified as Nascor NJ10 Wood Joists with 2x3 SPF Chords. The Wood Joists consisted of an Oriented Strand Board (OSB) web with 2x3 SPF Lumber Chords. The Chords were attached to the Web on edge, forming a Wood Joist measuring 1.5 inches wide by 9.5 inches high. (see drawing 1 in appendix for the Wood Joist profile)

The following tests were carried out on the submitted Wood Joists:

1. Bending Moment Capacity Tests
2. Shear Tests - Web Opening
   - Web to Web Joint
   - Through Web
3. Web to Chord Joint Shear Tests
4. Bearing Capacity Tests

WOOD JOISTS

1. Chords -

   The Chords were 2x3 SPF 2100 MSR Kiln Dried lumber. The moisture content at the time of manufacturing and when tested was between 9 and 12 percent. The relative density of the SPF Lumber chords was between 0.45 and 0.51. The Moisture Content was determined using the oven dry method based on the dry weight. The relative density measurement was conducted on the wet material by means of first measuring accurately cut samples followed by weighing them. The relative density was then calculated.

2. Webs -

   The Webs were 3/8 inch thick Oriented Strand Board (OSB) manufactured by Weyerhaeuser Ltd. The moisture content of the OSB at the time of manufacturing and when tested was between 2 and 3 percent. The relative density of the Web material was between 0.65 and 0.70. The Moisture Content and Relative Density was determined in a similar manner as the SPF Chords were.

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WOOD JOIST FABRICATION

The oriented strand board (OSB) webs were cut to the required width using a table saw. The long edges of the webs were then fed through a taper mill that produced the tapered male part of the web to chord joint. One end of the 8 foot long web section had a male part of a tongue and groove joint and the other end had the female part of a tongue and groove joint.

Slots were cut into one edge of the chord SPF lumber using a chord slotter. These slots received the tapered edge of the OSB web. The slots were the same profile as the taper and measured 19.0 mm deep by 8.4 mm at the surface and 5.9 mm at the base.

The web to chord and web to web joints were bonded using Phenol Resorcinol two part adhesive (LT75, FM265) manufactured by Borden Chemical.

Once the adhesive had been mixed, it was applied to the slots in the chords using the auto-gluer. The adhesive was applied to the male part of the web to web joint by dipping the male end of the 8 foot long web into the adhesive. The chords were placed on a conveyor table after the adhesive had been applied. The chords were then moved down the conveyor to the joist press.

Before the chords entered the press, they were set on flat and spread apart. A web section was then inserted into the slots of the chords at the end that enters the press first. The next web section was then fitted into the end of the first web section using the tongue and groove joint. Once enough web sections had been placed into the assembly, the entire joist assembly was then moved into the press where the components were pressed together to form the NASCOR joist.

Before the wood joist assembly was removed from the press, 25.4 mm (1 inch) staples were applied through the chords and web to hold the assembly together after removal from the press and before the adhesive set. The staples were applied to the top and bottom chords of the assembly on 24 inch centres.

The Nascor joists were then cured for minimum of 24 hours in the plant at room temperature. All joists were at least one week old before being tested.

TEST RESULTS

1. Bending Moment Capacity Tests

The submitted Wood Joists were tested in bending using lateral restraints. The load was applied equally at two locations located at third points over a 171 inch span. 28 samples were tested. Load versus deflection data was measured and recorded. Linear regressions were conduced for each test and the EI constant (stiffness) was calculated using the following formula:

$$EI = 23*S*1^3/648/2$$

where EI = stiffness
S = linear regression slope
1 = test span (171 inches)

The maximum load was also measured and recorded. The maximum bending moment was then calculated using the following formula:

$$M\ max = P*1/6$$

where P = total maximum load
1 = test span (171 inches)

Sample Number	Maximum Load(lbs)	Maximum Bending Moment(ft x lbs)	EI Value (lbs x ins^2)
1	3,620	8,600	1.84 x 10^8
2	4,170	9,910	1.69 x 10^8
3	5,485	13,025	1.79 x 10^8
4	5,230	12,420	1.78 x 10^8
5	4,610	10,950	1.66 x 10^8
6	3,530	8,385	1.41 x 10^8
7	4,220	10,020	1.64 x 10^8
8	3,835	9,110	1.58 x 10^8
9	4,145	9,850	1.51 x 10^8
10	4,590	10,900	1.67 x 10^8
11	4,655	11,060	1.75 x 10^8
12	4,215	10,005	1.44 x 10^8
13	2,950	7,005	1.48 x 10^8
14	3,215	7,630	1.60 x 10^8
15	2,950	7,005	1.70 x 10^8
16	4,135	9,820	1.63 x 10^8
17	4,170	9,890	1.70 x 10^8
18	4,300	10,220	1.73 x 10^8
19	5,005	11,880	1.85 x 10^8
20	4,085	9,700	1.44 x 10^8
21	4,050	9,620	1.76 x 10^8
22	5,105	12,125	1.72 x 10^8
23	4,625	10,985	1.68 x 10^8
24	5,315	12,620	1.88 x 10^8
25	3,750	8,910	1.83 x 10^8
26	4,710	11,190	1.97 x 10^8
27	4,235	10,060	1.59 x 10^8
28	2,370	5,630	1.46 x 10^8

TEST RESULTS (continued)

2. Shear Tests (Web to Web, Web Opening and Web Joint)

The Web to Web shear test was conducted on 16 samples. The samples were tested on a 36 inch span. A concentrated load was applied at the mid-span through a six inch long steel plate to avoid crushing of the chord. The samples had a 2 1/8 inch diameter hole in the web and a web to web joint located 12 inches from either reaction point. By having the hole and the web joint in these locations, their effect on the overall shear capacity of the Wood I-Joist could be determined. Failure modles are detailed in appendix appendix II.

Sample #	Load(lbs)	Failure Mode
1	8,400	Through joist in shear
2	7,490	Lower chord in tension
3	8,180	Glue line in shear
4	8,470	Lower chord in tension
5	9,580	Through joist in shear
6	9,325	Web flange hole in shear
7	9,840	Through joist in shear
8	6,890	Upper chord in compression
9	8,850	Web joist hole in shear
10	6,750	Web joint in shear
11	8,765	Upper chord in compression
12	8,850	Through joist in shear
13	8,080	Lower chord in tension
14	8,590	Lower chord in tension
15	8,595	Lower chord in tension
16	5,455	Web joist hole in shear

3. Web to Chord Joint Shear Tests

The Web to Chord shear tests were conducted on 4 inch long sections of the Wood Joists. The joint was tested by supporting the upper and lower chords and applying a load to the Web. The force required to shear the Web from the Chords was measured and recorded. The Web to Web joint cross-sectional area was measured. The Web to Web joint strength was then calculated in pounds per square inch.

Sample #	Shear Strength (psi)	Failure Mode
1	331.2	40% wood
2	355.2	Web bending failure
3	419.7	Web bending failure
4	270.7	100% wood
5	341.2	95% wood
6	365.3	100% wood
7	357.2	Web bending failure
8	406.9	95% wood
9	420.6	100% wood
10	371.5	100% wood
11	331.2	100% wood
12	367.4	Web bending failure
13	441.2	Web bending failure
14	264.8	Web bending failure
15	390.9	Web bending failure

4. Bearing Capacity Tests

The samples were tested for bearing capacity using various lengths of Wood Joists. The cut samples were tested in compression. The maximum load capacity of the long joist sections was measured and recorded. Thirty samples were tested, ten without reinforcement, ten with a 5/8 inch thick OSB stiffener on one side of the web and ten with a 5/8 inch thick OSB stiffener on both sides of the web. The web stiffeners were installed using two 1 1/2 inch common nails per side with a 1/8 inch gap between the web stiffener and the upper chord.

Sample #	Length(ins)	Reinforcement	Maximum Load(lbs)
1	10	none	5,390
2	4	none	2,695
3	4	none	3,320
4	3	none	2,500
5	3	none	3,560
6	3	none	2,215
7	3	none	2,385
8	3	none	3,375
9	3	none	2,555
10	3	none	2,120
11	3	OSB one side	2,325
12	3	OSB one side	2,400
13	3	OSB one side	2,165
14	3	OSB one side	2,890
15	3	OSB one side	2,160
16	3	OSB one side	2,600
17	3	OSB one side	2,380
18	3	OSB one side	2,260
19	3	OSB one side	2,240
20	3	OSB one side	2,570
21	3	OSB two sides	3,730
22	3	OSB two sides	3,810
23	3	OSB two sides	3,770
24	3	OSB two sides	3,270
25	3	OSB two sides	3,885
26	3	OSB two sides	2,975
27	3	OSB two sides	2,675

4. Bearing Capacity Tests (continued)

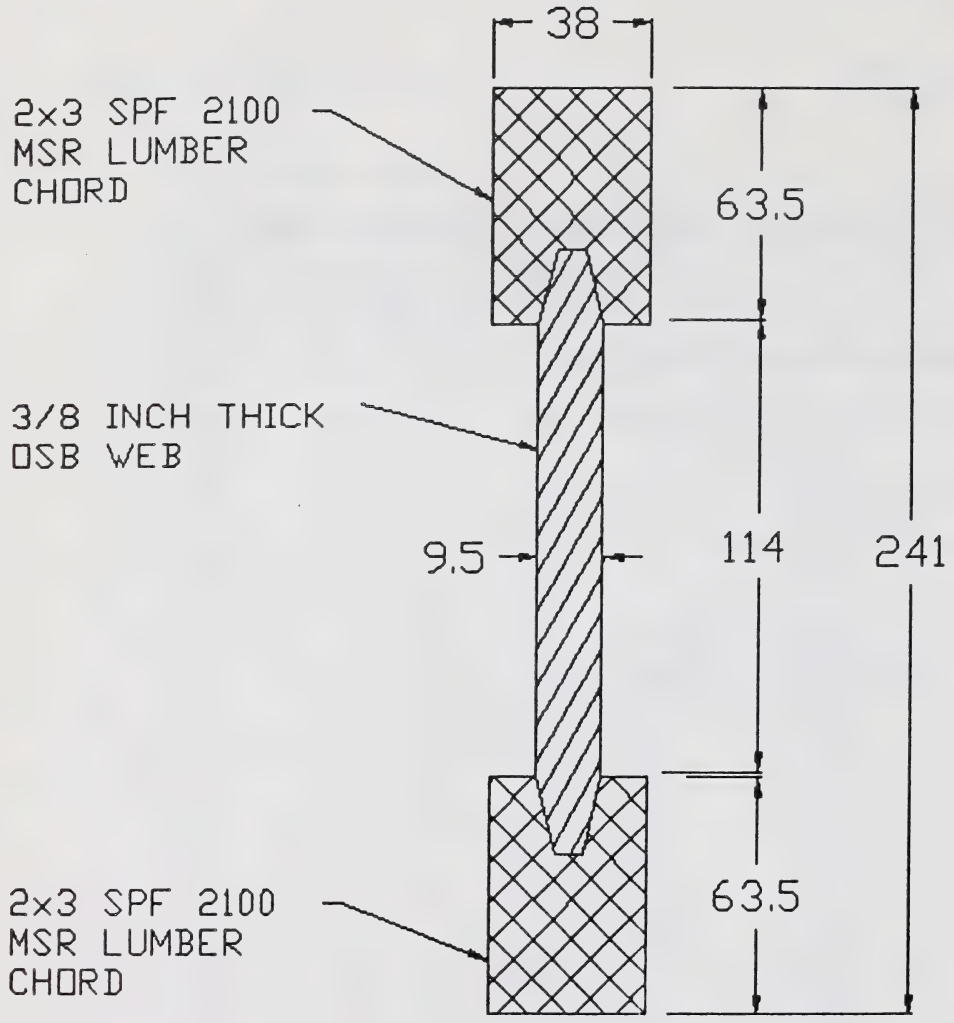
Sample #	Length(ins)	Reinforcement	Maximum Load(lbs)
28	3	OSB two sides	2,970
29	3	OSB two sides	2,960
30	3	OSB two sides	2,750

WARNOCK HERSEY PROFESSIONAL SERVICES LTD.

Reported by: _____
Paul Arnold
Supervisor
Materials Testing Division

Reviewed by: _____
Farid Mawani, P.Eng.
Manager, Field Services
Physical Testing Division

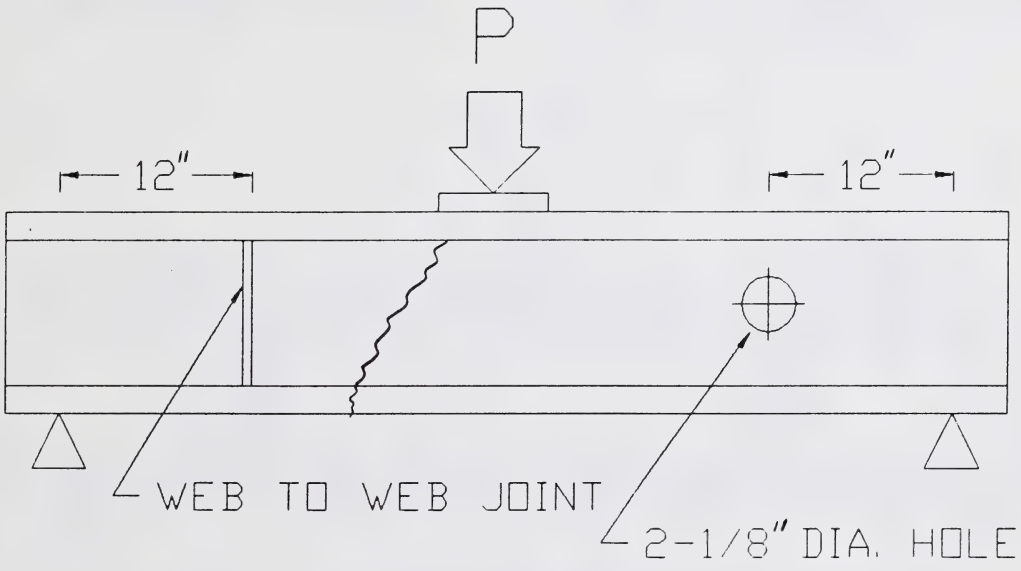
PA/cr



SECTION THROUGH JOIST

NASCOR INCORPORATED		DWG. 1 OF 1
NJ 2X10 WOOD JOISTS		
AUG. 30, 1990	SCALE: N.T.S.	DRG. BY: PA

JOIST TYPE : NJ 10 DATE : AUG 3 1 1990
TEST NUMBER : 1 P MAX: 8400 Lbs



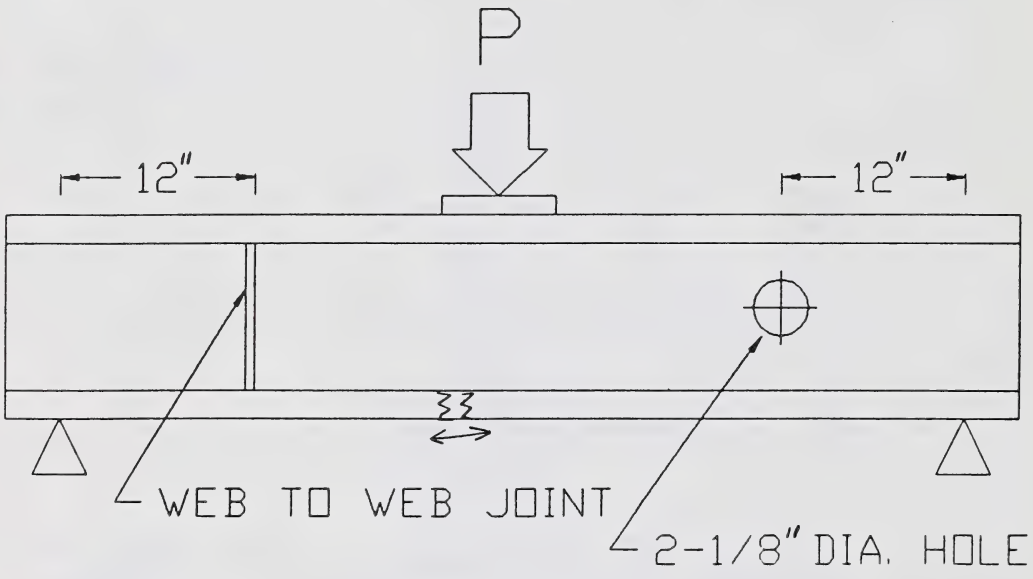
NOTES: Through joist in shear

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1
SHEAR TEST FAILURE MODE		OF 1
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ 10 DATE : AUG 3 1 1990

TEST NUMBER : 2 P MAX: 7490 lbs.



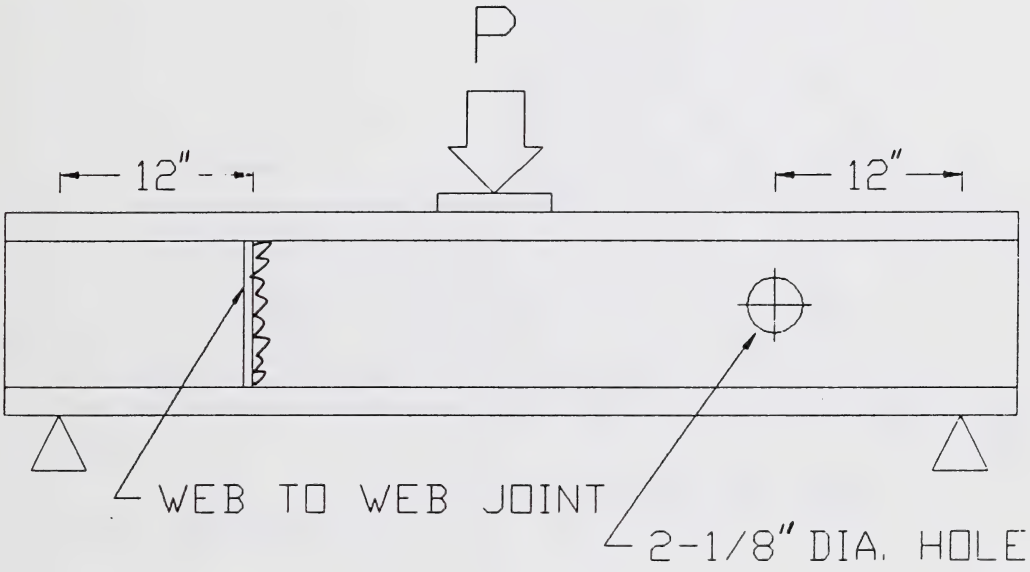
NOTES: Lower chord in tension.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ 10 DATE : AUG 3 1 1990

TEST NUMBER : 3 P MAX: 8180



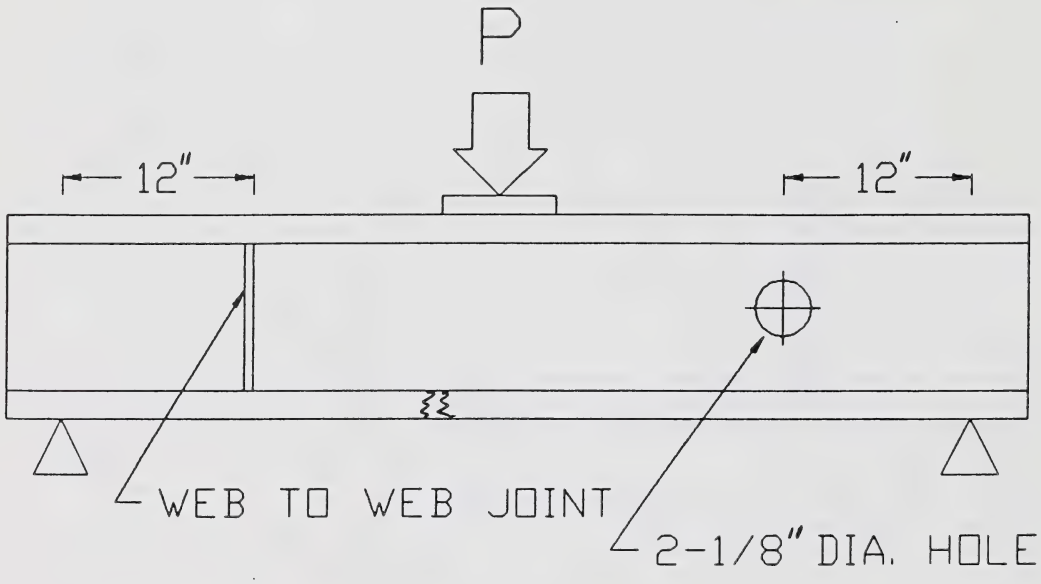
NOTES: Glue line of Web Joint in shear.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ 10 DATE : AUG 3 1 1990

TEST NUMBER : 4 P MAX: 8470 lbs.



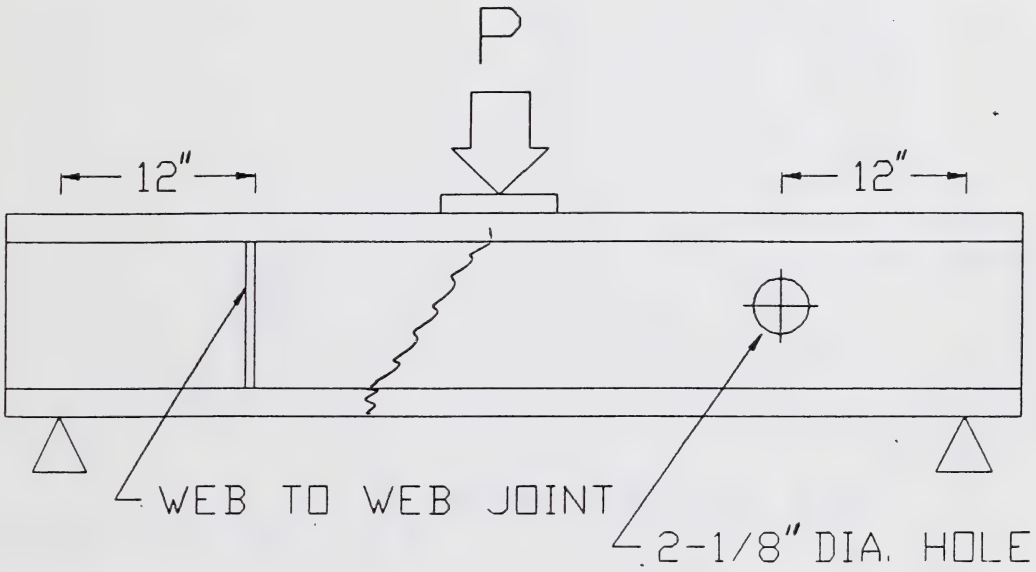
NOTES: Lower chord in tension.

SHEAR CAPACITY TEST

NASCOR INCORPORATED	DWG. 1 OF 1
SHEAR TEST FAILURE MODE	
DATE: 91-01-31 / SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ10 DATE : AUG 3 1 1990

TEST NUMBER : 5 P MAX: 9580 lbs.



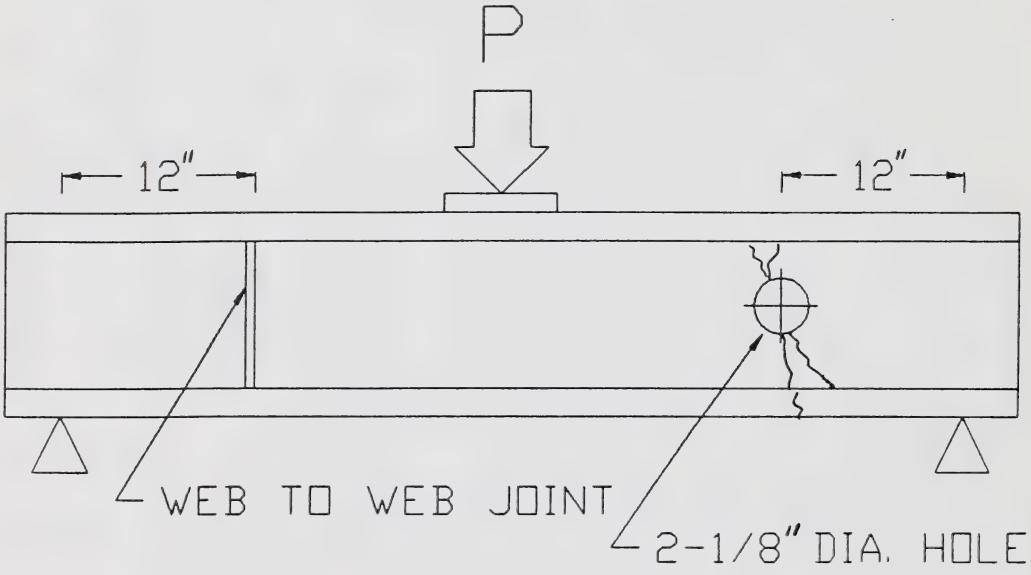
NOTES: Through Joist in shear.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ10 DATE : AUG 3 1 1990

TEST NUMBER : 6 P MAX: 9325 lbs



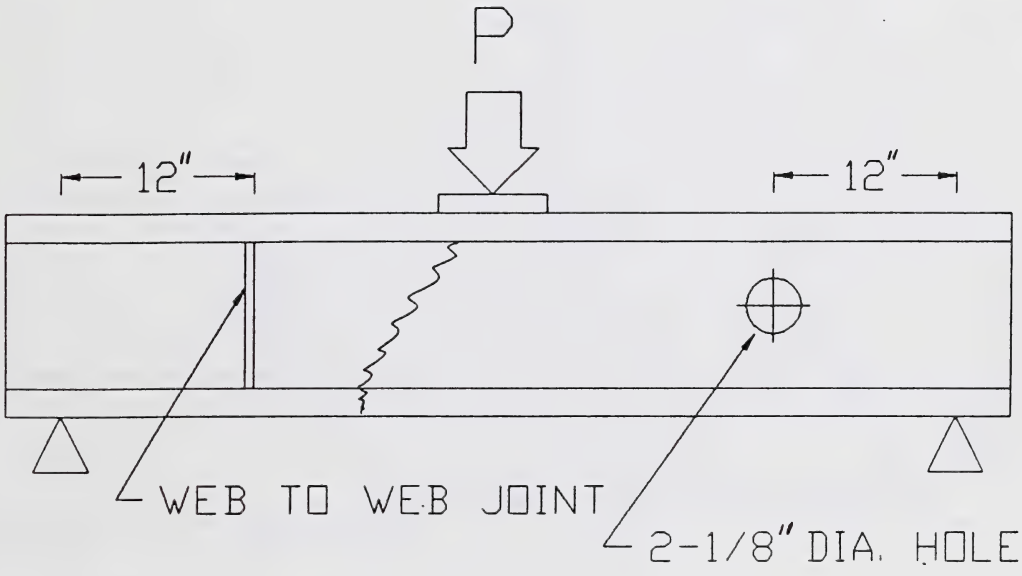
NOTES: Web flange hole in shear.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ 10 DATE : AUG 3 1 1990

TEST NUMBER : 7 P MAX: 9840 lbs



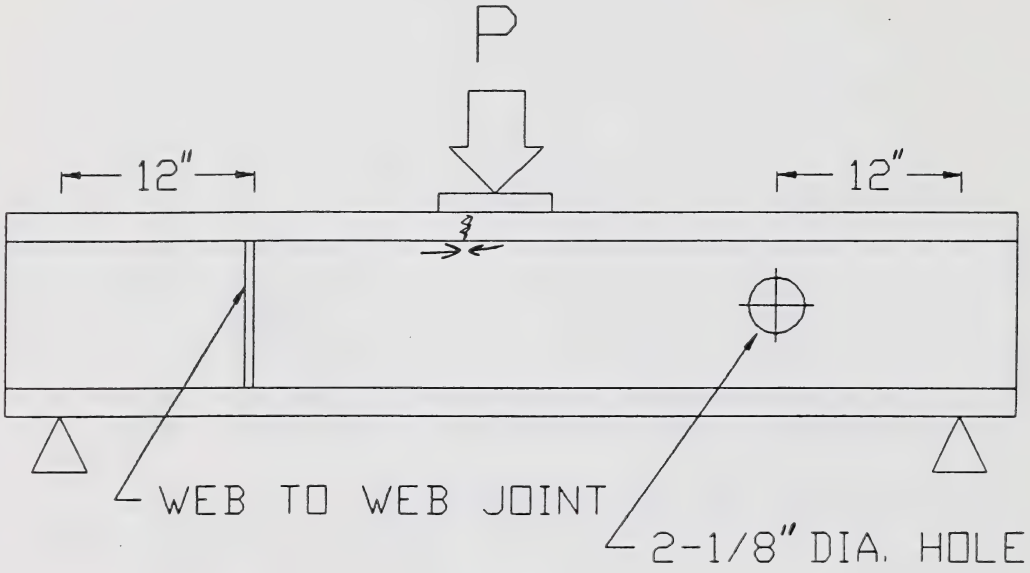
NOTES: Through joist in shear.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1
SHEAR TEST FAILURE MODE		OF 1
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ10 DATE : AUG 3 1 1990

TEST NUMBER : B P MAX: 6890 lbs



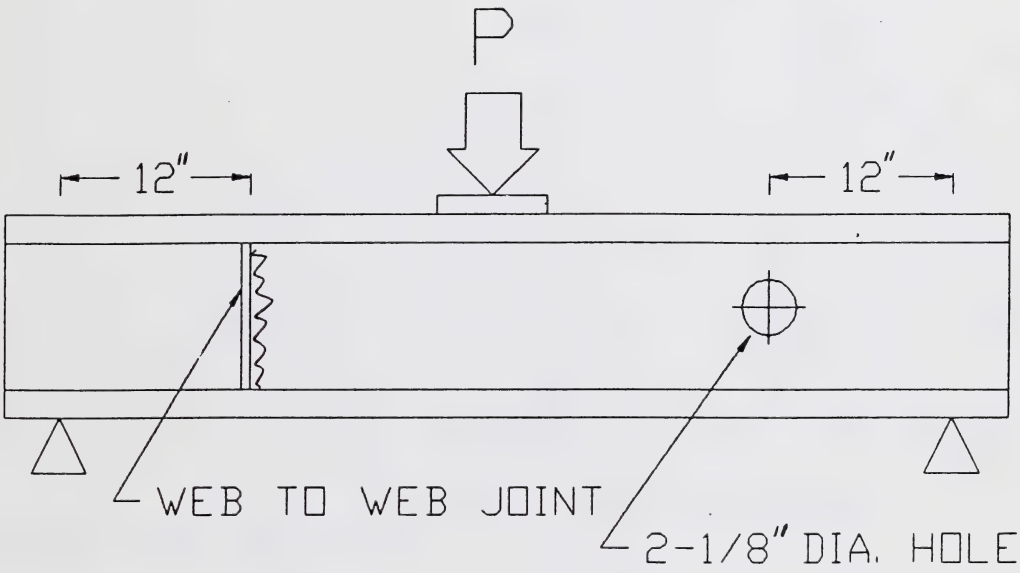
NOTES: Upper chord in compression

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ 10 DATE : AUG 3 1 1990

TEST NUMBER : 10 P MAX: 6750 lbs.



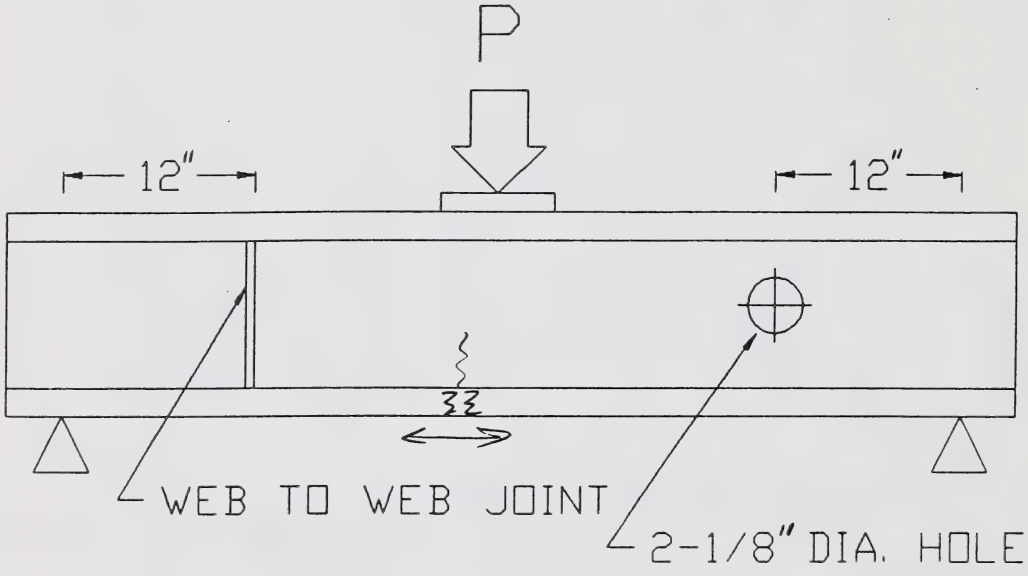
NOTES: Web joint in shear.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE.		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ10 DATE : AUG 3 1 1990

TEST NUMBER : 14 P MAX: 8590 lbs



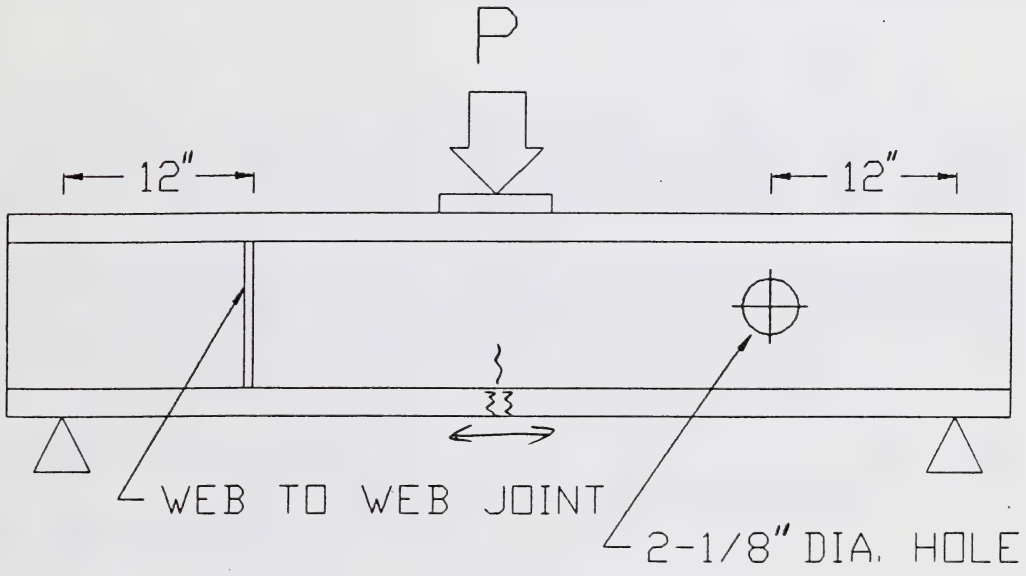
NOTES: Lower chord in tension.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ 10 DATE : AUG 3 1 1990

TEST NUMBER : 15 P MAX: 8595 lbs.



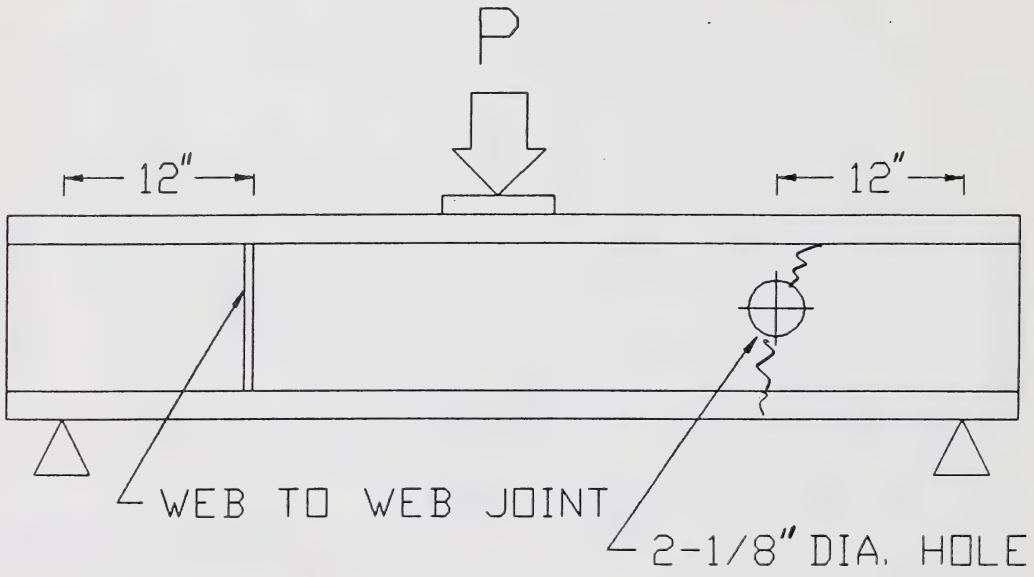
NOTES: Lower chord in tension.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ 10 DATE : AUG 3 1 1990

TEST NUMBER : 16 P MAX: 5455 lbs



NOTES: Web joist hole in shear.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

Warnock Hersey Professional Services Ltd.
211 Schoolhouse St., Coquitlam, B.C. V3K 4X9 - (604) 520-3321 - Telecopier (604) 524-9186

REPORT OF: Wood Joist Structural Testing

AT: Coquitlam, B.C. DATE Aug. 30/90

PROJECT: 50485-C7-719500 REPORT NO: 5/90 Rev.

REPORTED TO: Nascor Incorporated
7803P - 35 Street S.E.
Calgary, Alberta
T2C 1V3

ORDER NO.

Revised: February 1, 1991
Attention: Soa Hoang

NJ12 -ASTM

INTRODUCTION

As requested, we have conducted Physical Tests on samples of Wood Joists submitted to our laboratory by Nascor Inc. The submitted Wood Joists were tested in accordance with the proposed American Society of Testing and Materials (ASTM) Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists.

The submitted Wood I-Joists were identified as Nascor NJ12 Wood Joists with 2x3 SPF Chords. The Wood Joists consisted of an Oriented Strand Board (OSB) web with 2x3 SPF Lumber Chords. The Chords were attached to the Web on edge, forming a Wood Joist measuring 1.5 inches wide by 11.875 inches high. (see drawing 1 in appendix for the Wood Joist profile.)

The following tests were carried out on the submitted Wood Joists:

1. Bending Moment Capacity Tests
2. Shear Tests - Web Opening
   - Web to Web Joint
   - Through Web
3. Web to Chord Joint Shear Tests
4. Bearing Capacity Tests

WOOD JOIST MATERIALS

1. Chords -

   The Chords were 2x3 SPF 2100 MSR Kiln Dried lumber. The moisture content at the time of manufacturing and when tested was between 9 and 12 percent. The relative density of the SPF Lumber chords was between 0.45 and 0.51. The Moisture Content was determined using the oven dry method based on the dry weight. The relative density measurement was conducted on the wet material by means of first measuring accurately cut samples followed by weighing them. The relative density was then calculated.

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WOOD JOIST MATERIALS (continued)

2. Webs -

The Webs were 3/8 inch thick Oriented Strand Board (OSB) manufactured by Weyerhaeuser Ltd. The moisture content of the OSB at the time of manufacturing and when tested was between 2 and 3 percent. The relative density of the Web material was between 0.65 and 0.70. The Moisture Content and Relative Density was determined in a similar manner as the SPF Chords were.

WOOD JOIST FABRICATION

The oriented strand board (OSB) webs were cut to the required width using a table saw. The long edges of the webs were then fed through a taper mill that produced the tapered male part of the web to chord joint. One end of the 8 foot long web section had a male part of a tongue and groove joint and the other end had the female part of a tongue and groove joint.

Slots were cut into one edge of the chord SPF lumber using a chord slotter. These slots received the tapered edge of the OSB web. The slots were the same profile as the taper and measured 19.0 mm deep by 8.4 mm at the surface and 5.9 mm at the base.

The web to chord and web to web joints were bonded using Phenol Resorcinol two part adhesive (LT75, FM265) manufactured by Borden Chemical.

Once the adhesive had been mixed, it was applied to the slots in the chords using the auto-gluer. The adhesive was applied to the male part of the web to web joint by dipping the male end of the 8 foot long web into the adhesive. The chords were placed on a conveyor table after the adhesive had been applied. The chords were then moved down the conveyor to the joist press.

Before the chords entered the press, they were set on flat and spread apart. A web section was then inserted into the slots of the chords at the end that enters the press first. The next web section was then fitted into the end of the first web section using the tongue and groove joint. Once enough web sections had been placed into the assembly, the entire joist assembly was then moved into the press where the components were pressed together to form the NASCOR joist.

Before the wood joist assembly was removed from the press, 25.4 mm (1 inch) staples were applied through the chords and web to hold the assembly together after removal from the press and before the adhesive set. The staples were applied to the top and bottom chords of the assembly on 24 inch centres.

The Nascor joists were then cured for minimum of 24 hours in the plant at room temperature. All joists were at least one week old before being tested.

TEST RESULTS

1. Bending Moment Capacity Tests

The submitted Wood Joists were tested in bending using lateral restraints. The load was applied equally at two locations located at third points over a 213 inch span. 28 samples were tested. Load versus deflection data was measured and recorded. Linear regressions were conduced for each test and the EI constant (stiffness) was calculated using the following formula:

$$EI = 23*S*1^3/648/2$$

where EI = stiffness
S = linear regression slope
1 = test span (213 inches)

The maximum load was also measured and recorded. The maximum bending moment was then calculated using the following formula:

$$M\ max = P*1/6$$

where P = total maximum load
1 = test span (213 inches)

Sample Number	Maximum Load(lbs)	Maximum Bending Moment(ft x lbs)	EI Value (lbs x ins^2)
1	4,535	13,410	2.82 x 10^8
2	5,410	16,020	2.79 x 10^8
3	5,655	16,730	3.03 x 10^8
4	4,460	13,185	3.01 x 10^8
5	4,180	12,400	2.74 x 10^8
6	4,260	12,600	2.81 x 10^8
7	4,260	12,600	2.81 x 10^8
8	4,445	13,150	2.92 x 10^8
9	4,410	13,035	3.03 x 10^8
10	4,375	12,940	2.62 x 10^8
11	4,385	12,970	2.72 x 10^8
12	4,140	12,250	2.79 x 10^8
13	4,120	12,200	2.50 x 10^8
14	4,540	13,420	2.74 x 10^8
15	3,920	11,600	2.90 x 10^8
16	4,770	14,110	2.90 x 10^8
17	5,520	16,325	3.22 x 10^8
18	4,980	14,730	2.87 x 10^8
19	5,210	15,400	3.21 x 10^8
20	5,500	16,270	2.92 x 10^8
21	4,690	13,875	3.18 x 10^8
22	4,700	13,900	2.76 x 10^8
23	4,265	12,610	2.56 x 10^8
24	5,810	17,180	3.14 x 10^8
25	5,110	15,120	2.83 x 10^8
26	4,515	13,350	2.69 x 10^8
27	4,170	12,330	2.90 x 10^8
28	4,590	13,580	2.86 x 10^8

TEST RESULTS (continued)

2. Shear Tests (Web to Web, Web Opening and Web Joint)

The Web to Web shear test was conducted on 15 samples. The samples were tested on a 42 inch span. A concentrated load was applied at the mid-span through a six inch long steel plate to avoid crushing of the chord. The samples had a 2 1/8 inch diameter hole in the web and a web to web joint located 12 inches from either reaction point. By having the hole and the web joint in these locations, their effect on the overall shear capacity of the Wood I-Joist could be determined. Failure mode details are included in appendix II.

Sample #	Load(lbs)	Failure Mode
1	8,600	Lower chord in tension
2	8,470	Upper chord in compression
3	8,470	Upper chord in compression
4	8,965	Through joist in shear
5	8,965	Web shear through hole
6	8,740	Upper chord in compression
7	8,500	Web shear diagonally
8	8,375	Upper chord in compression
9	8,375	Lower chord in tension
10	7,990	Lower chord in tension
11	9,265	Lower chord in tension
12	8,935	Through joist in shear
13	8,840	Lower chord in tension
14	8,600	Web shear diagonally
15	8,155	Lower chord in tension

3. Web to Chord Joint Shear Tests

The Web to Chord shear tests were conducted on 4 inch long sections of the Wood Joists. The samples were actually taken from Nascor NJ 2x12 Wood Joists. However the joint in the Nascor NJ 2x12 Wood Joist is identical to the joint in the Nascor NJ 2x12 Wood Joist. The joint was tested by supporting the upper and lower chords and applying a load to the Web. The force required to shear the Web from the Chords was measured and recorded. The Web to Web joint cross-sectional area was measured. The Web to Web joint strength was then calculated in pounds per square inch.

Sample #	Shear Strength(psi)	Failure Mode
1	331.2	40% wood
2	355.2	Web bending failure
3	419.7	Web bending failure
4	270.7	100% wood
5	341.2	95% wood
6	365.3	100% wood
7	357.2	Web bending failure
8	406.9	95% wood
9	420.6	100% wood
10	371.5	100% wood

TEST RESULTS (continued)

3. Web to Chord Joint Shear Tests (continued)

Sample #	Shear Strength(psi)	Failure Mode
11	331.2	100% wood
12	367.4	Web bending failure
13	441.2	Web bending failure
14	264.8	Web bending failure
15	390.9	Web bending failure

4. Bearing Capacity Tests

The samples were tested for bearing capacity using 3 inch long sections of the Wood Joists. The cut samples were tested in compression. The maximum load capacity of the 3 inch long joist sections was measured and recorded. Thirty samples were tested, ten without reinforcement, ten with a 5/8 inch thick OSB stiffener on one side of the web and ten with a 5/8 inch thick OSB stiffener on both sides of the web. The web stiffeners were installed using two 1 1/2 inch common nails per side with a 1/8 inch gap between the web stiffener and the upper chord.

Sample #	Reinforcement	Maximum Load(lbs)
1	none	1,770
2	none	2,090
3	none	2,155
4	none	2,075
5	none	1,640
6	none	2,380
7	none	1,650
8	none	1,760
9	none	1,640
10	none	2,020
11	OSB one side	2,610
12	OSB one side	2,480
13	OSB one side	2,490
14	OSB one side	2,215
15	OSB one side	2,560
16	OSB one side	2,100
17	OSB one side	2,090
18	OSB one side	2,225
19	OSB one side	2,345
20	OSB one side	2,520
21	OSB two sides	2,600
22	OSB two sides	2,850
23	OSB two sides	3,080
24	OSB two sides	2,560
25	OSB two sides	3,100

TEST RESULTS (continued)

4. Bearing Capacity Tests

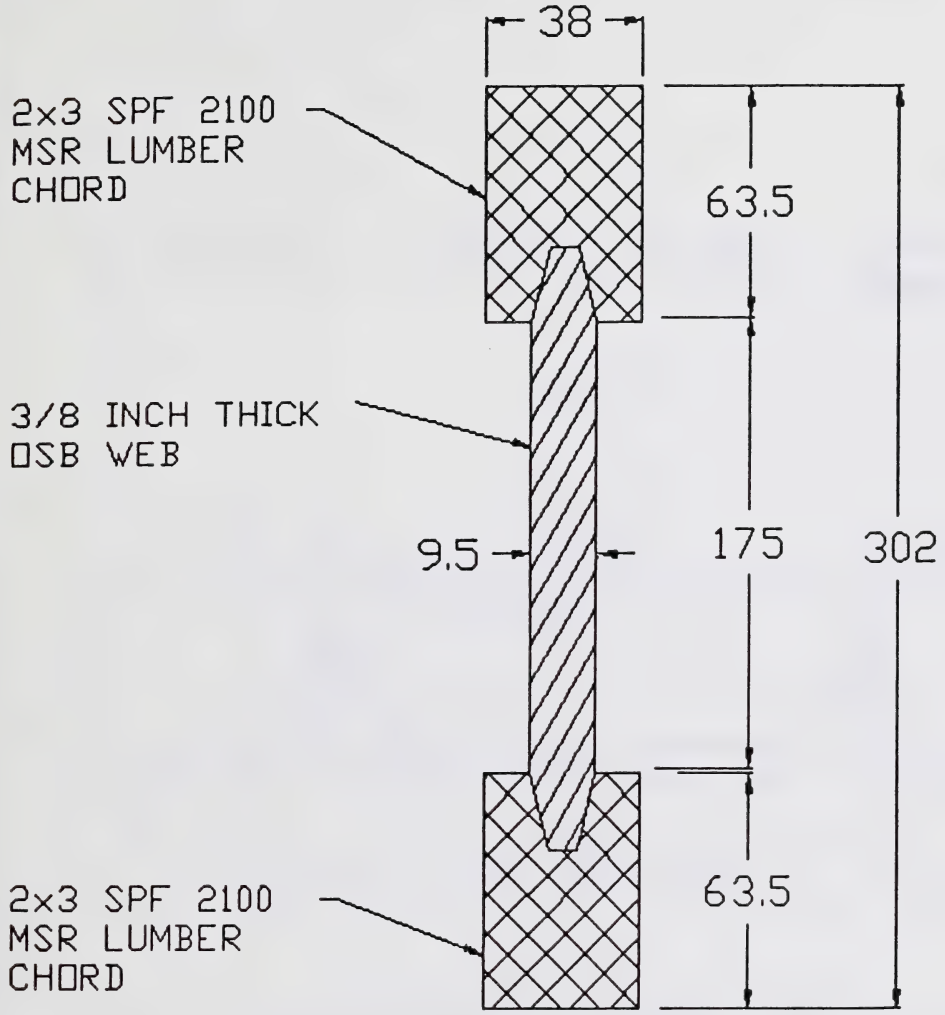
Sample #	Reinforcement	Maximum Load(lbs)
26	OSB two sides	2,855
27	OSB two sides	3,125
28	OSB two sides	2,600
29	OSB two sides	2,910
30	OSB two sides	2,790

WARNOCK HERSEY PROFESSIONAL SERVICES LTD.

Reported by: _____
Paul Arnold
Supervisor
Materials Testing Division

Reviewed by: _____
Farid Mawani, P.Eng.
Manager, Field Services
Physical Testing Division

PA/cr

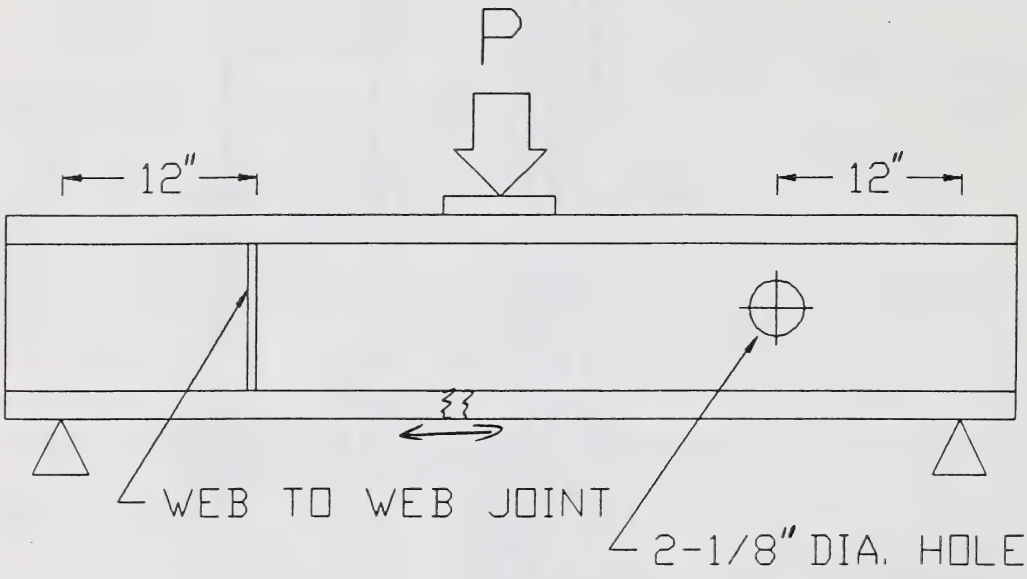


SECTION THROUGH JOIST

NASCOR INCORPORATED		DWG. 1 OF 1
NJ 2X12 WOOD JOISTS		
AUG. 30, 1990	SCALE: N.T.S.	DRG. BY: PA

JOIST TYPE : NJ12 DATE : AUG 28 1990

TEST NUMBER : 1 P MAX: 8600 lbs.



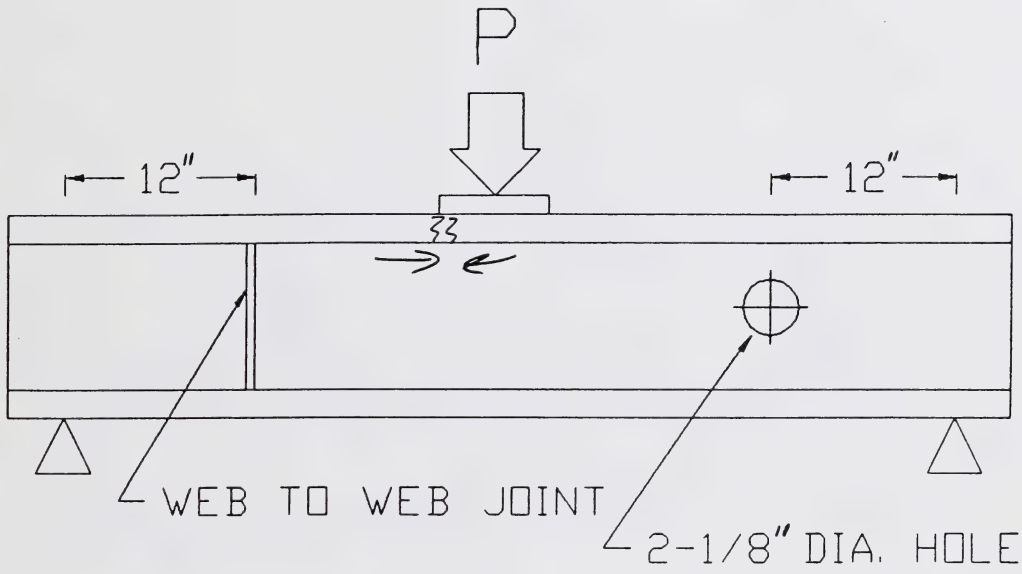
NOTES: Lower chord in tension.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1
SHEAR TEST FAILURE MODE		OF 1
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ 12 DATE : AUG 2 8 19[illegible]

TEST NUMBER : 2 P MAX: 8470



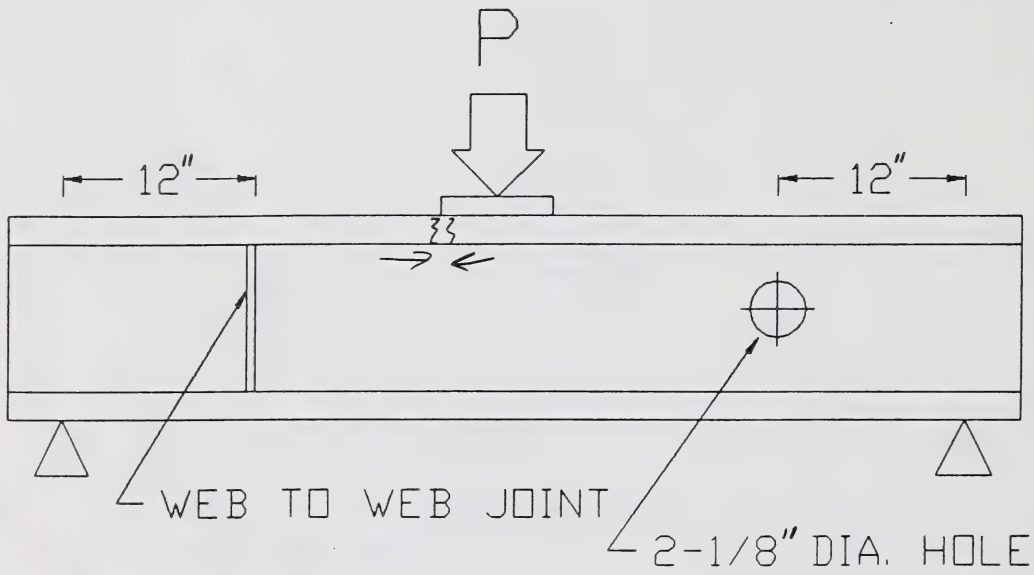
NOTES: Upper chord in compression

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ 12 DATE : AUG 2 8 1990

TEST NUMBER : 3 P MAX: 8470 lbs

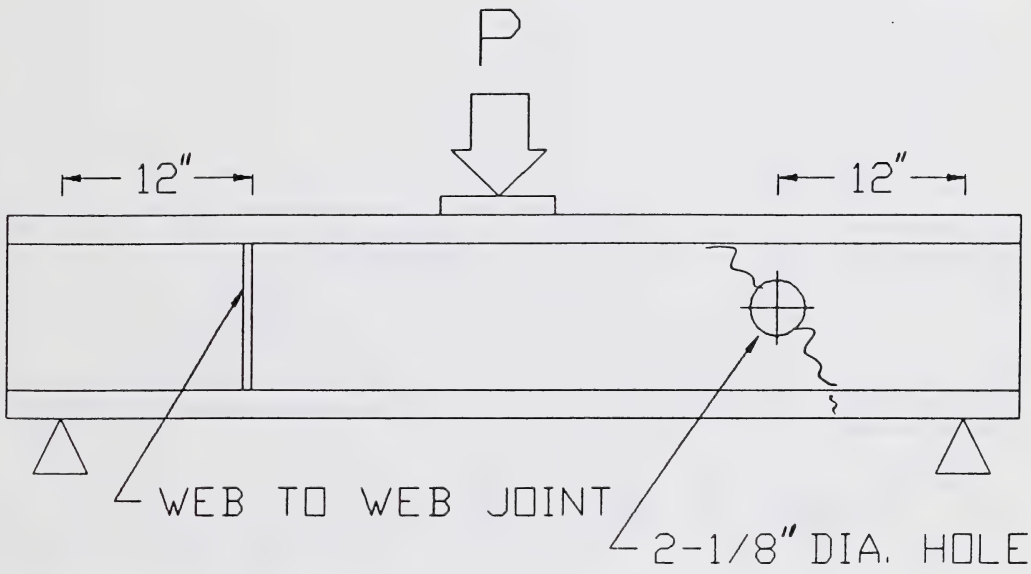


NOTES: Upper chord in compression

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ12 DATE : AUG 2 8 1990
TEST NUMBER : 4 P MAX: 8965 lbs



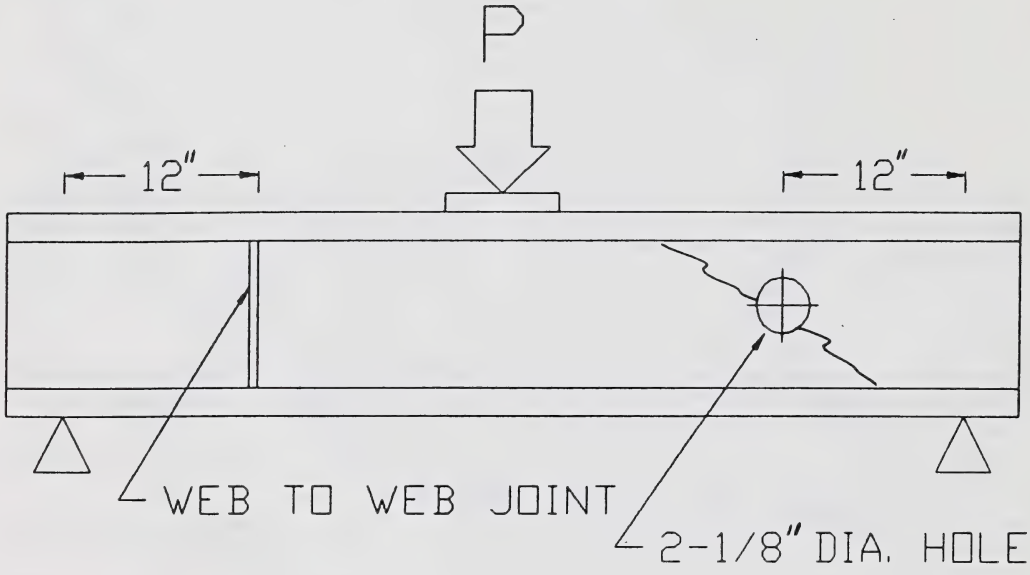
NOTES: Through joist hole in sheer.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ12 DATE : AUG 2 8 1990

TEST NUMBER : 5 P MAX: 8965 lbs.



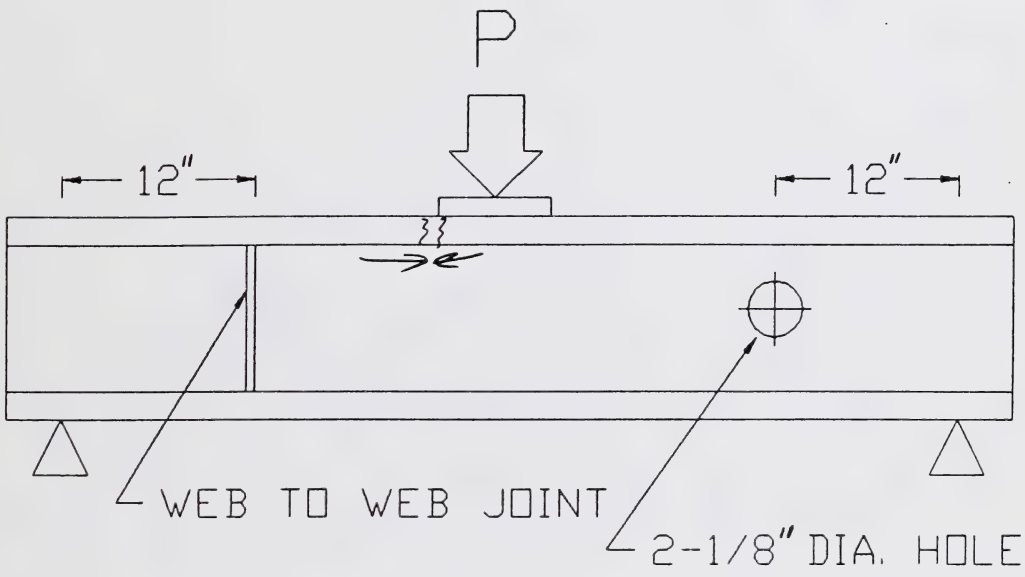
NOTES: Web shear through hole.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ 12 DATE : AUG 2 8 1990

TEST NUMBER : 6 P MAX: 8740 lbs.



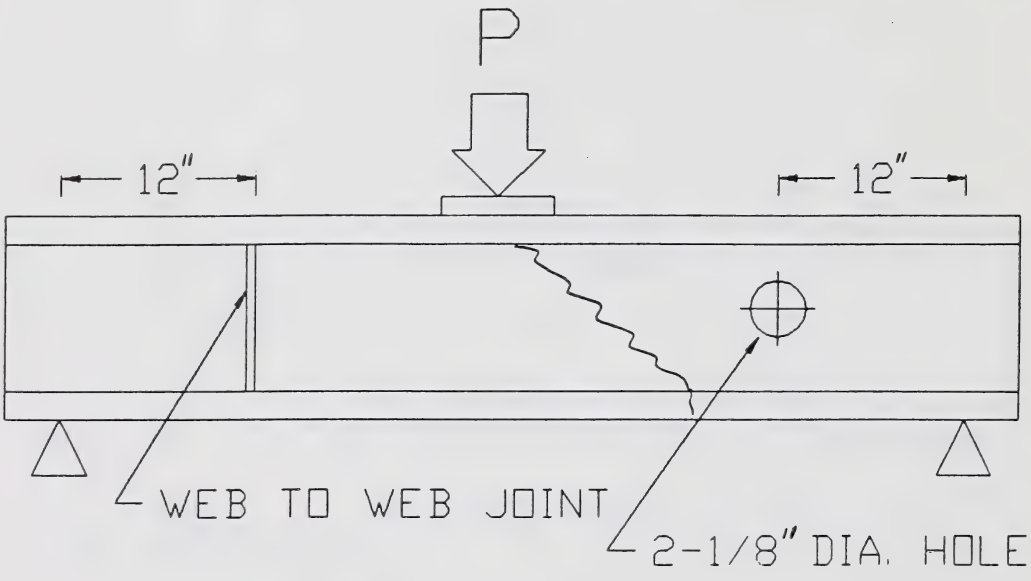
NOTES: Upper chord in compression

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ12 DATE : AUG 2 8 1990

TEST NUMBER : 7 P MAX: 8500 lbs



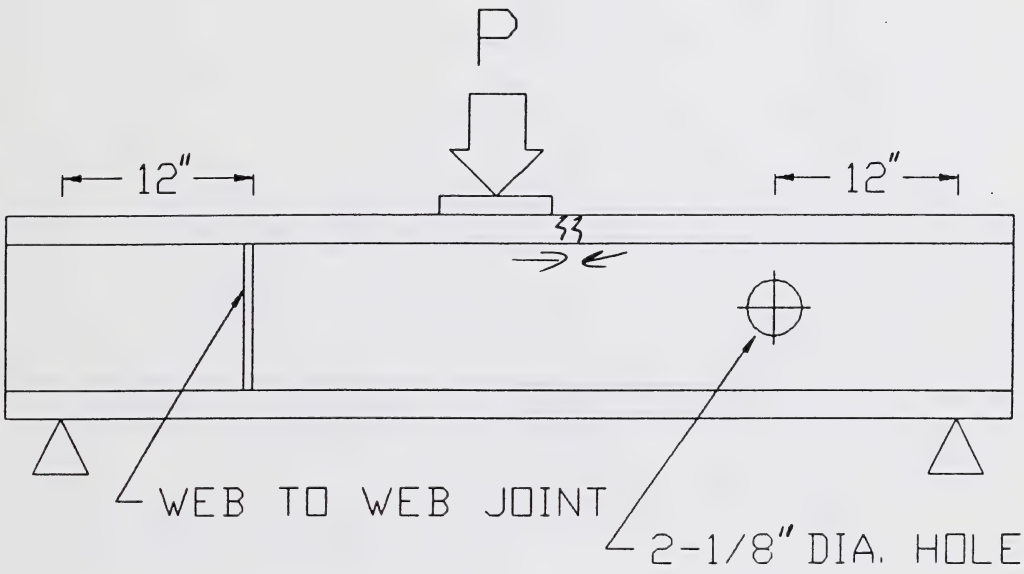
NOTES: Web shear

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1
SHEAR TEST FAILURE MODE		OF 1
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ12 DATE : AUG 2 8 1990

TEST NUMBER : 8 P MAX: 8375 lbs

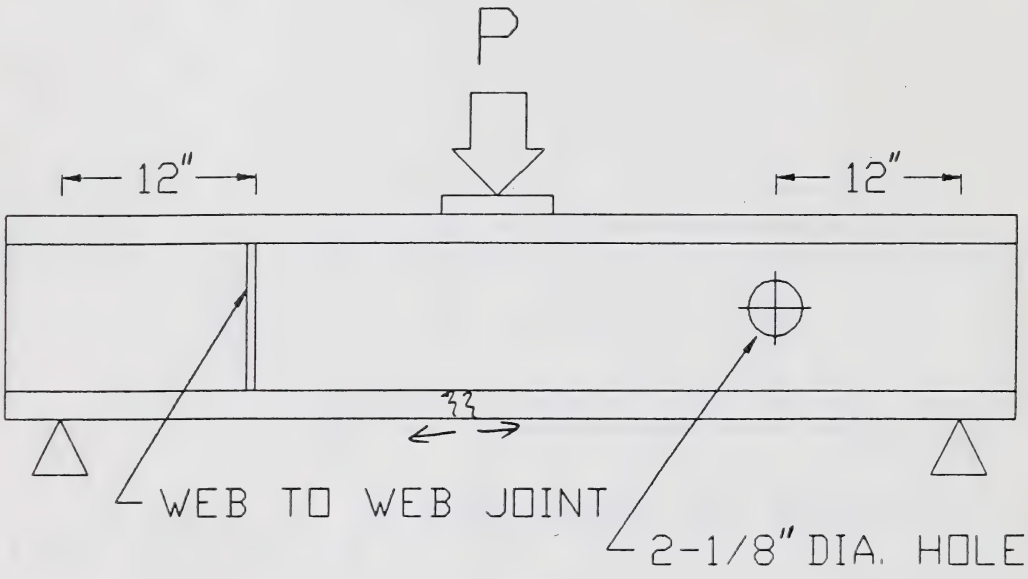


NOTES: Upper chord in compression.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ12 DATE : AUG 28 1990
TEST NUMBER : 9 P MAX: 8375 lbs



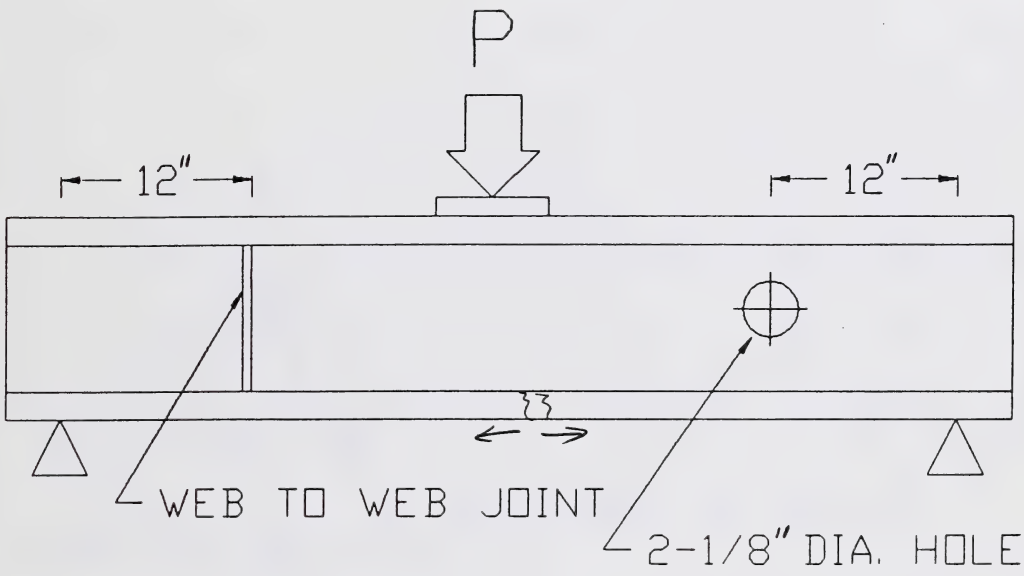
NOTES: Lower chord in tension.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ 12 DATE : AUG 2 8 1990

TEST NUMBER : 10 P MAX: 7990 lbs.



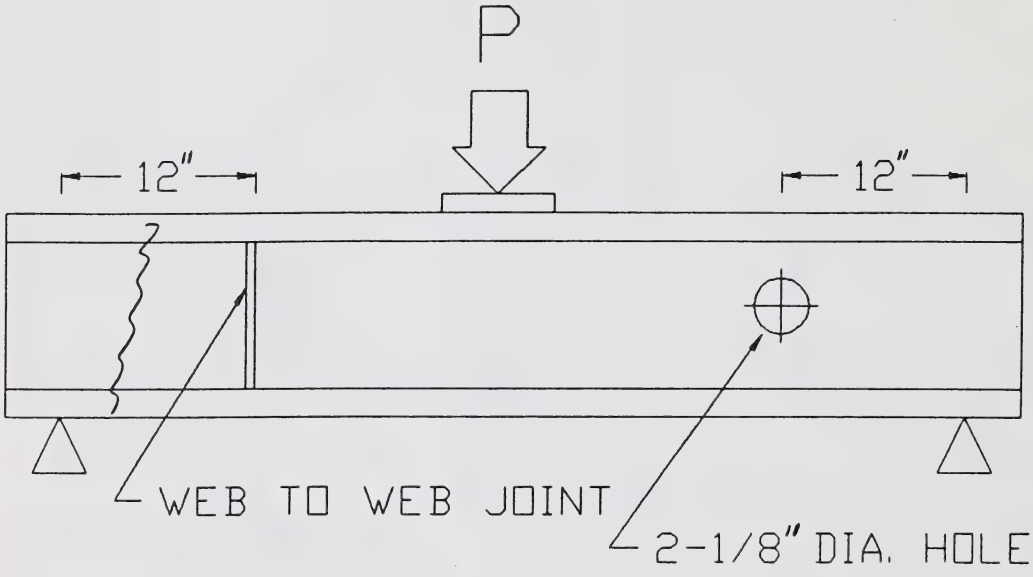
NOTES: Lower chord in tension.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ 12 DATE : AUG 2 8 1990

TEST NUMBER : 12 P MAX: 8935 lbs



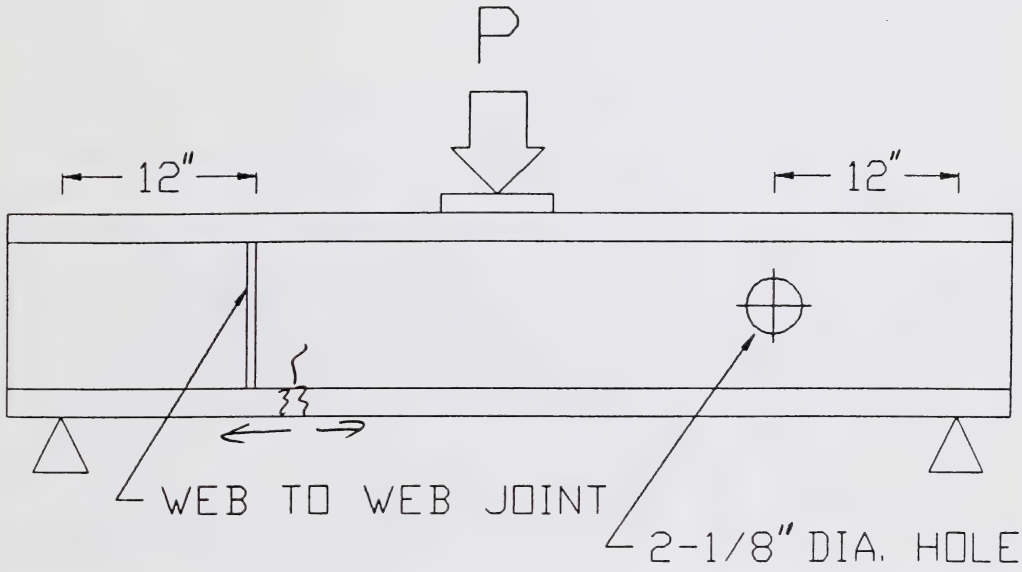
NOTES: Through joist in shear.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ12 DATE : AUG 2 8 1990

TEST NUMBER : 13 P MAX: 8840 lbs



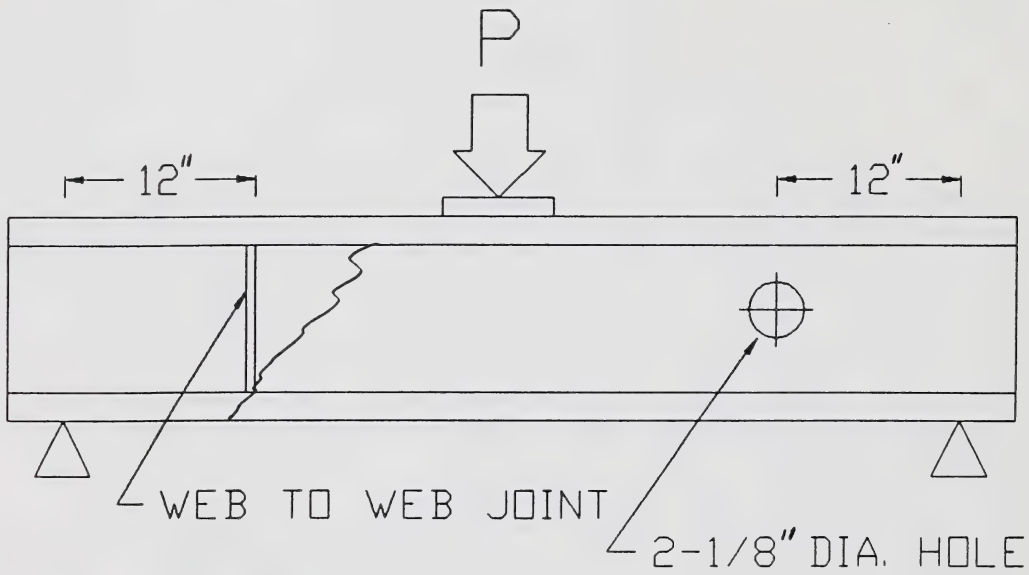
NOTES: Lower chord in tension

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ12 DATE : AUG 2 8 1990

TEST NUMBER : 14 P MAX: 8600 lbs

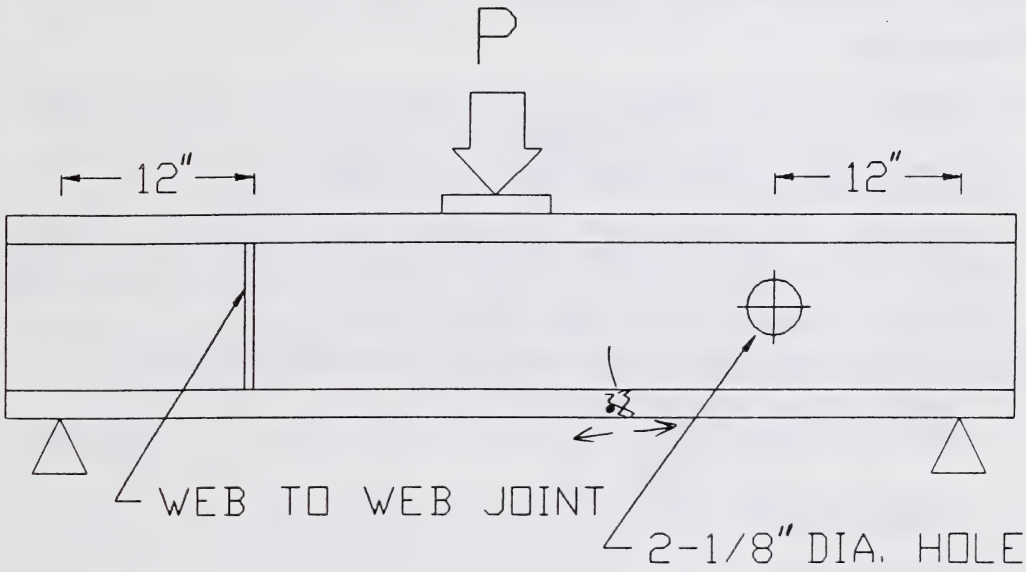


NOTES: Web shear

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJ12 DATE : AUG 2 8 1990
TEST NUMBER : 15 P MAX: 8155 lbs



NOTES: Lower chord in tension at a knot.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

Warnock Hersey Professional Services Ltd.
211 Schoolhouse St., Coquitlam, B.C. V3K 4X9 - (604) 520-3321 - Telecopier (604) 524-9186

REPORT OF: Physical Tests on Wood Joists

AT: Coquitlam Laboratory DATE Aug.31/90

PROJECT: 50484-C7-719500 REPORT NO: 8/90 Rev.

REPORTED TO: Nascor Incorporated
7803P - 35 Street S.E.
Calgary, Alberta
T2C 1V3

ORDER NO.

Revised: February 1, 1991
Attention: Soa Hoang

NJS12 - ASTM

INTRODUCTION

As requested, we have conducted Physical Tests on samples of Wood Joists submitted to our laboratory by Nascor Inc. The submitted Wood Joists were tested in accordance with the proposed American Society of Testing and Materials (ASTM) Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists.

The submitted Wood I-Joists were identified as Nascor NJS12 Wood Joists with 2x4 SPF Chords. The Wood Joists consisted of an Oriented Strand Board (OSB) web with 2x4 SPF Lumber Chords. The Chords were attached to the Web on edge, forming a Wood Joist measuring 1.5 inches wide by 11.875 inches high. (see drawing 1 in appendix for the Wood Joist profile)

The following tests were carried out on the submitted Wood Joists:

1. Bending Moment Capacity Tests
2. Shear Tests - Web Opening
   - Web to Web Joint
   - Through Web
3. Web to Chord Joint Shear Tests
4. Bearing Capacity Tests

WOOD JOIST MATERIALS

1. Chords -

   The Chords were 2x4 SPF 2100 MSR Kiln Dried lumber. The moisture content at the time of manufacturing and when tested was between 9 and 12 percent. The relative density of the SPF Lumber chords was between 0.45 and 0.51. The Moisture Content was determined using the oven dry method based on the dry weight. The relative density measurement was conducted on the wet material by means of first measuring accurately cut samples followed by weighing them. The relative density was then calculated.

2. Webs -

   The Webs were 3/8 inch thick Oriented Strand Board (OSB) manufactured by Weyerhaeuser Ltd. The moisture content of the OSB at the time of manufacturing and when tested was between 2 and 3 percent. The relative density of the Web material was between 0.65 and 0.70. The Moisture Content and Relative Density was determined in a similar manner as the SPF Chords were.

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WOOD JOIST FABRICATION

The oriented strand board (OSB) webs were cut to the required width using a table saw. The long edges of the webs were then fed through a taper mill that produced the tapered male part of the web to chord joint. One end of the 8 foot long web section had a male part of a tongue and groove joint and the other end had the female part of a tongue and groove joint.

Slots were cut into one edge of the chord SPF lumber using a chord slotter. These slots received the tapered edge of the OSB web. The slots were the same profile as the taper and measured 19.0 mm deep by 8.4 mm at the surface and 5.9 mm at the base.

The web to chord and web to web joints were bonded using Phenol Resorcinol two part adhesive (LT75, FM265) manufactured by Borden Chemical.

Once the adhesive had been mixed, it was applied to the slots in the chords using the auto-gluer. The adhesive was applied to the male part of the web to web joint by dipping the male end of the 8 foot long web into the adhesive. The chords were placed on a conveyor table after the adhesive had been applied. The chords were then moved down the conveyor to the joist press.

Before the chords entered the press, they were set on flat and spread apart. A web section was then inserted into the slots of the chords at the end that enters the press first. The next web section was then fitted into the end of the first web section using the tongue and groove joint. Once enough web sections had been placed into the assembly, the entire joist assembly was then moved into the press where the components were pressed together to form the NASCOR joist.

Before the wood joist assembly was removed from the press, 25.4 mm (1 inch) staples were applied through the chords and web to hold the assembly together after removal from the press and before the adhesive set. The staples were applied to the top and bottom chords of the assembly on 24 inch centres.

The Nascor joists were then cured for minimum of 24 hours in the plant at room temperature. All joists were at least one week old before being tested.

TEST RESULTS

1. Bending Moment Capacity Tests

The submitted Wood Joists were tested in bending using lateral restraints. The load was applied equally at two locations located at third points over a 213 inch span. 28 samples were tested. Load versus deflection data was measured and recorded. Linear regressions were conduced for each test and the EI constant (stiffness) was calculated using the following formula:

$$EI = 23*S*1^3/648/2$$

where EI = stiffness
S = linear regression slope
1 = test span (213 inches)

The maximum load was also measured and recorded. The maximum bending moment was then calculated using the following formula:

$$M\ max = P*1/6$$

where P = total maximum load
1 = test span (213 inches)

Sample Number	Maximum Load(lbs)	Maximum Bending Moment(ft x lbs)	EI Value (lbs x ins^2)
1	4,945	14,625	2.96 x 10^8
2	5,265	15,575	3.48 x 10^8
3	5,370	15,885	2.98 x 10^8
4	6,340	18,760	3.14 x 10^8
5	5,800	17,150	2.85 x 10^8
6	6,050	17,900	2.72 x 10^8
7	5,360	15,860	2.92 x 10^8
8	6,625	19,600	2.98 x 10^8
9	5,745	16,990	3.10 x 10^8
10	6,780	20,055	3.07 x 10^8
11	5,090	15,060	3.30 x 10^8
12	5,215	15,420	3.11 x 10^8
13	7,190	21,270	2.95 x 10^8
14	5,740	16,980	2.97 x 10^8
15	7,570	22,390	3.23 x 10^8
16	5,940	17,575	3.09 x 10^8
17	5,495	16,250	3.02 x 10^8
18	5,390	15,940	3.12 x 10^8
19	5,310	15,715	2.97 x 10^8
20	5,335	15,775	3.26 x 10^8
21	4,740	14,015	2.67 x 10^8
22	4,080	12,070	3.00 x 10^8
23	4,820	14,255	3.24 x 10^8
24	3,925	11,610	2.91 x 10^8
25	4,755	14,070	2.96 x 10^8
26	4,975	14,720	3.01 x 10^8
27	5,120	15,145	2.97 x 10^8
28	5,210	15,415	2.99 x 10^8

TEST RESULTS (continued)

2. Shear Tests (Web to Web, Web Opening and Web Joint)

The Web to Web shear test was conducted on 15 samples. The samples were tested on a 42 inch span. A concentrated load was applied at the mid-span through the six inch long steel plate to avoid crushing of the chord. The samples had a 2 1/8 inch diameter hole in the web and a web to web joint located 12 inches from either reaction point. By having the hole and the web joint in these locations, their effect on the overall shear capacity of the Wood I-Joist could be determined. Failure models are detailed in appendix II.

Sample #	Load(lbs)	Failure Mode
1	10,200	Lower chord in tension
2	8,950	Lower chord in tension
3	9,270	Lower Web/Flange joint
4	8,670	Lower chord in tension
5	7,575	Upper chord in compression
6	8,285	Upper chord in compression
7	7,420	Upper chord in compression
8	7,920	Web/Web joint in shear
9	7,395	Upper chord in compression
10	9,340	Lower chord in tension
11	9,165	Through joist in shear
12	8,905	Through joist in shear
13	8,320	Upper chord in compression
14	8,905	Web in shear
15	8,935	Lower chord in tension

3. Web to Chord Joint Shear Tests

The Web to Chord shear tests were conducted on 4 inch long sections of the Wood Joists. The samples were actually taken from Nascor NJ 2x10 Wood Joists. However the joints in the Nascor NJ 2x10 Wood Joists are identical to the joint used in the Nascor NJ 2x12 Wood Joist. The joint was tested by supporting the upper and lower chords and applying a load to the Web. The force required to shear the Web from the Chords was measured and recorded. The Web to Web joint cross-sectional area was measured. The Web to Web joint strength was then calculated in pounds per square inch.

Sample #	Shear Strength(psi)	Failure Mode
1	331.2	40% wood
2	355.2	Web bending failure
3	419.7	Web bending failure
4	270.7	100% wood
5	341.2	95% wood
6	365.3	100% wood
7	357.2	Web bending failure
8	406.9	95% wood
9	420.6	100% wood
10	371.5	100% wood
11	331.2	100% wood
12	367.4	Web bending failure
13	441.2	Web bending failure
14	264.8	Web bending failure
15	390.9	Web bending failure

TEST RESULTS (continued)

4. Bearing Capacity Tests

The samples were tested for bearing capacity using 4 inch long sections of the Wood Joists. The cut samples were tested in compression. The maximum load capacity of the 4 inch long joist sections was measured and recorded. Thirty samples were tested, ten without reinforcement, ten with a 5/8 inch thick OSB stiffener on one side of the web and ten with a 5/8 inch thick OSB stiffener on both sides of the web. The web stiffeners were installed using two 1 1/2 inch common nails per side with a 1/8 inch gap between the web stiffener and the upper chord.

Sample #	Reinforcement	Maximum Load(lbs)
1	none	2,545
2	none	2,520
3	none	2,840
4	none	2,615
5	none	2,845
6	none	2,610
7	none	2,575
8	none	2,510
9	none	2,725
10	none	2,890
11	OSB one side	3,240
12	OSB one side	3,290
13	OSB one side	3,090
14	OSB one side	3,555
15	OSB one side	3,450
16	OSB one side	3,490
17	OSB one side	3,375
18	OSB one side	3,225
19	OSB one side	3,175
20	OSB one side	3,250
21	OSB two sides	4,015
22	OSB two sides	4,100
23	OSB two sides	3,995
24	OSB two sides	4,075
25	OSB two sides	3,950
26	OSB two sides	3,900
27	OSB two sides	4,025

TEST RESULTS (continued)

4. Bearing Capacity Tests (continued)

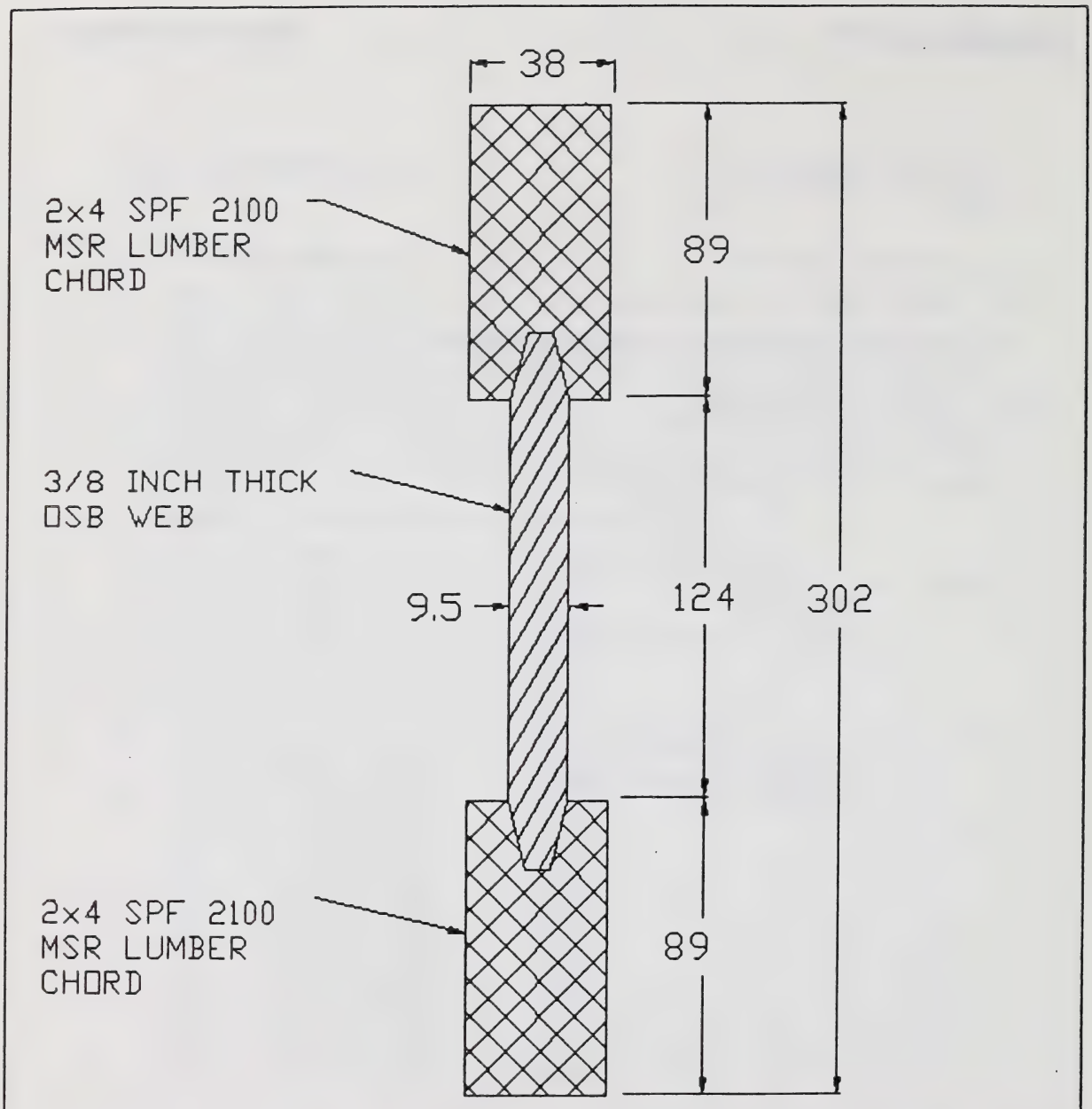
Sample #	Reinforcement	Maximum Load(lbs)
28	OSB two sides	3,995
29	OSB two sides	4,175
30	OSB two sides	4,015

WARNOCK HERSEY PROFESSIONAL SERVICES LTD.

Reported by: _____
Paul Arnold
Supervisor
Materials Testing Division

Reviewed by: _____
Farid Mawani, P.Eng.
Manager, Field Services
Physical Testing Division

PA/cr

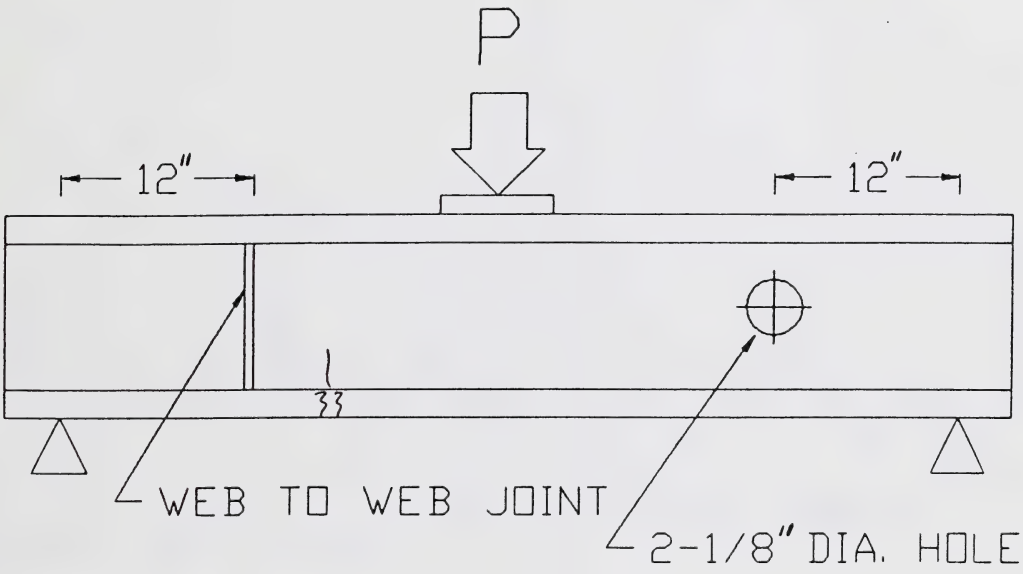


SECTION THROUGH JOIST

NASCOR INCORPORATED		DWG. 1 OF 1
NJ 2X12 WOOD JOISTS		
AUG. 30, 1990	SCALE: N.T.S.	DRG. BY: PA

JOIST TYPE : NJS12 DATE : AUG 31 1990

TEST NUMBER : 1 P MAX: 10,200



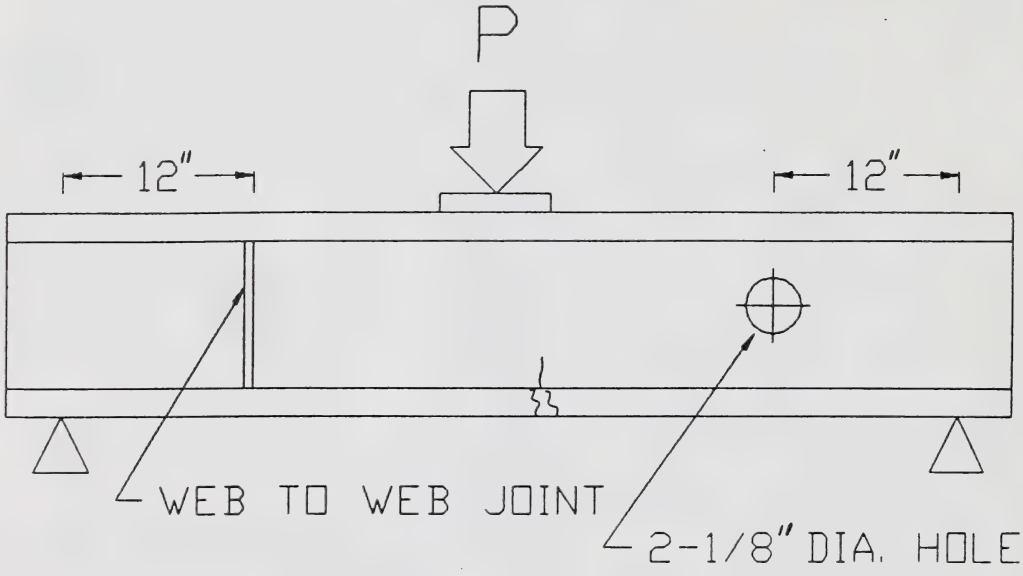
NOTES: Lower chord in tension.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJS12 DATE : AUG 3 1 1990

TEST NUMBER : 2 P MAX: 8950



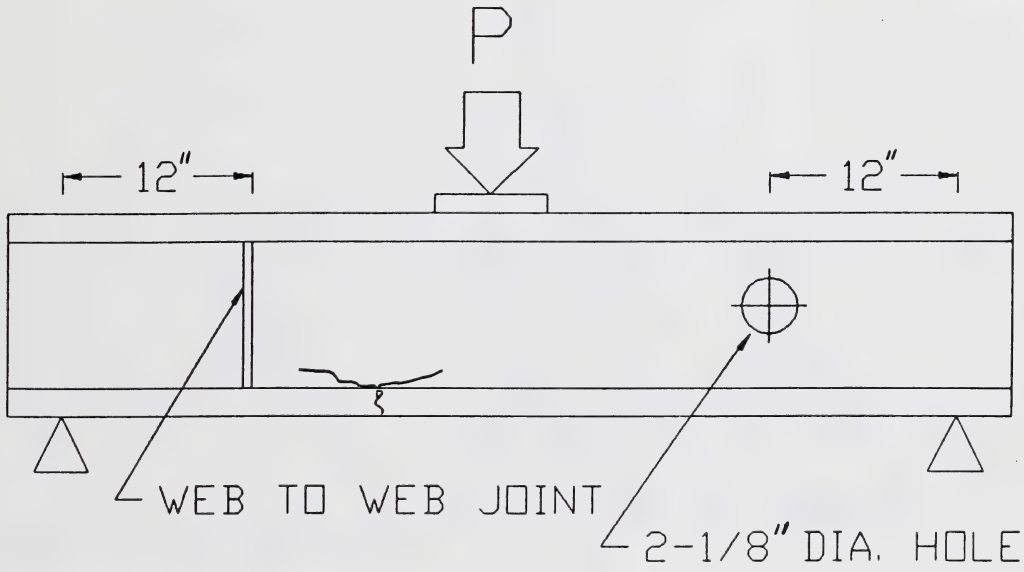
NOTES: Lower chord in tension.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJS12 DATE : AUG 31 1990

TEST NUMBER : 3 P MAX: 9270 lbs

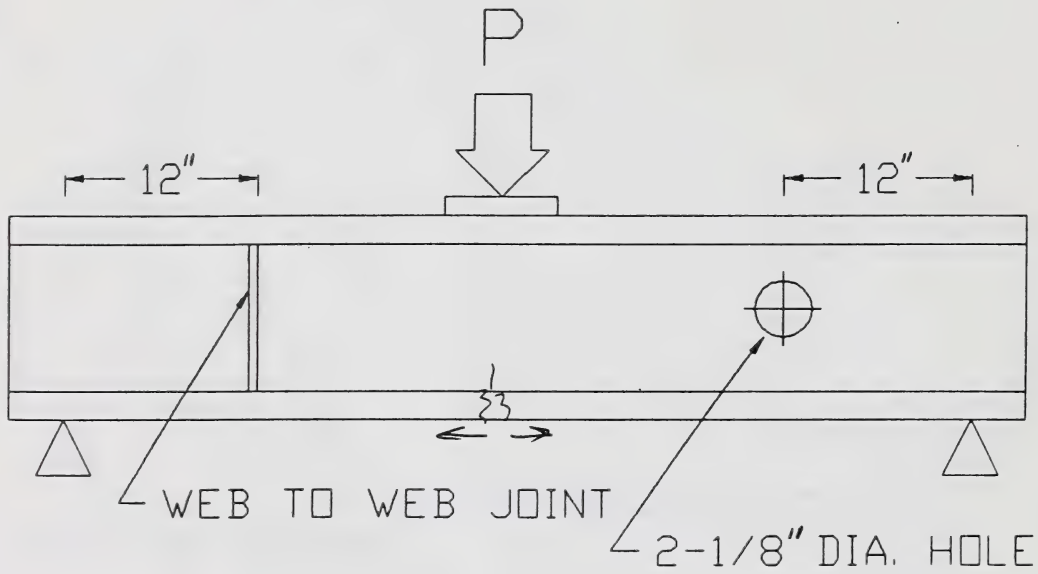


NOTES: Lower web/flange joint and lower chord in tension.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJS12 DATE : AUG 31 1990
TEST NUMBER : 4 P MAX: 8670 lbs.

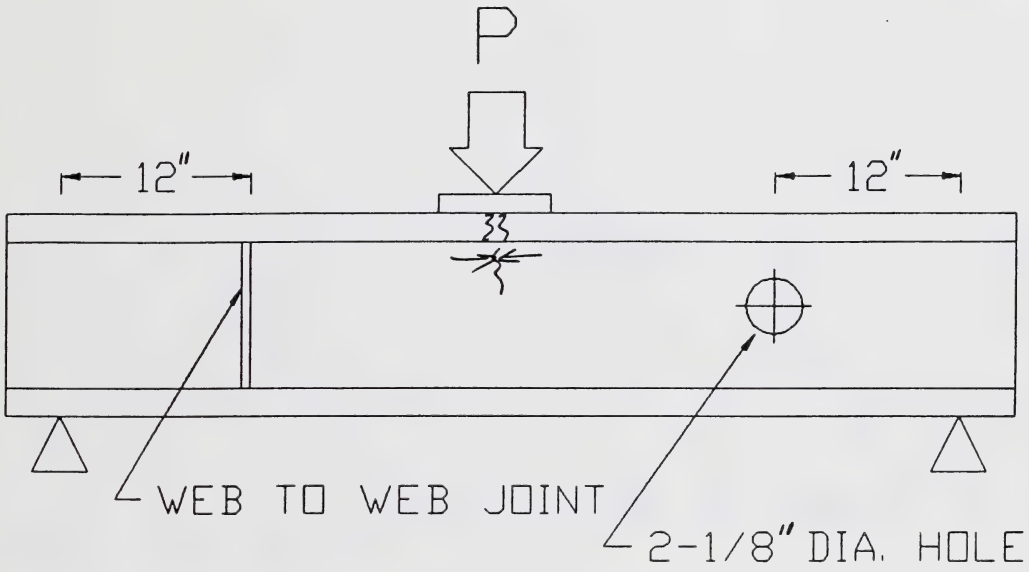


NOTES: Lower chord in tension.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJS12 DATE : AUG 31 1990
TEST NUMBER : 5 P MAX: 7575 lbs.



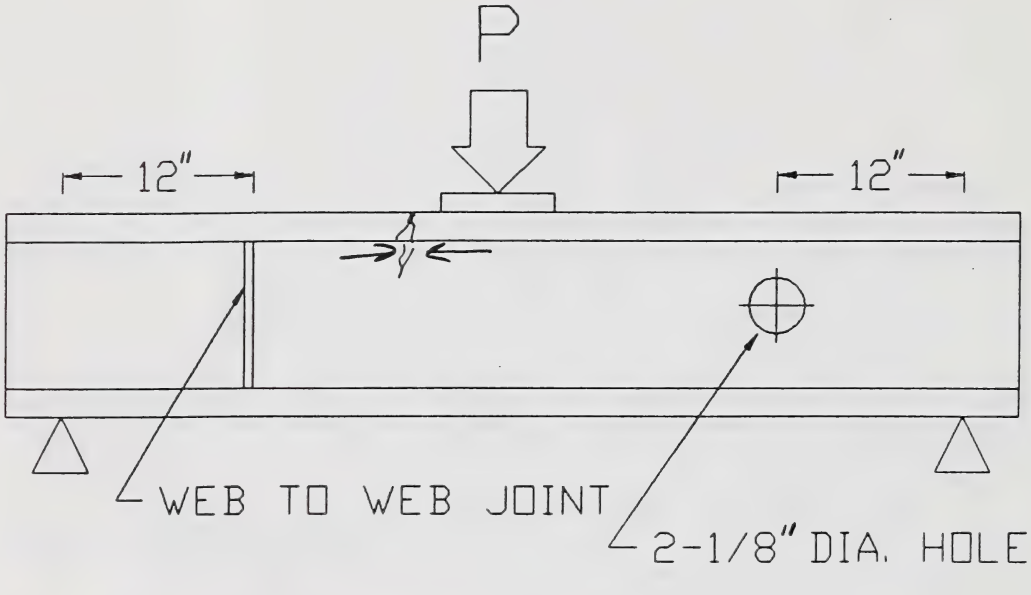
NOTES: Upper chord in compression.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJS12 DATE : AUG 31 1990

TEST NUMBER : 6 P MAX: 8285 lbs



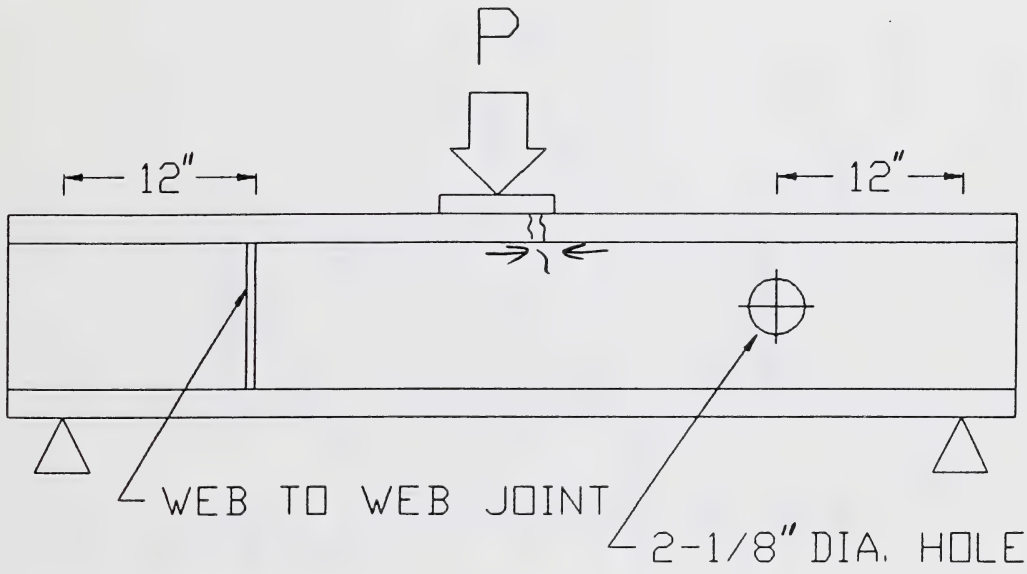
NOTES: Upper chord in compression

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1
SHEAR TEST FAILURE MODE		OF 1
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJS12 DATE : AUG 31 1990

TEST NUMBER : 7 P MAX: 7420 lbs



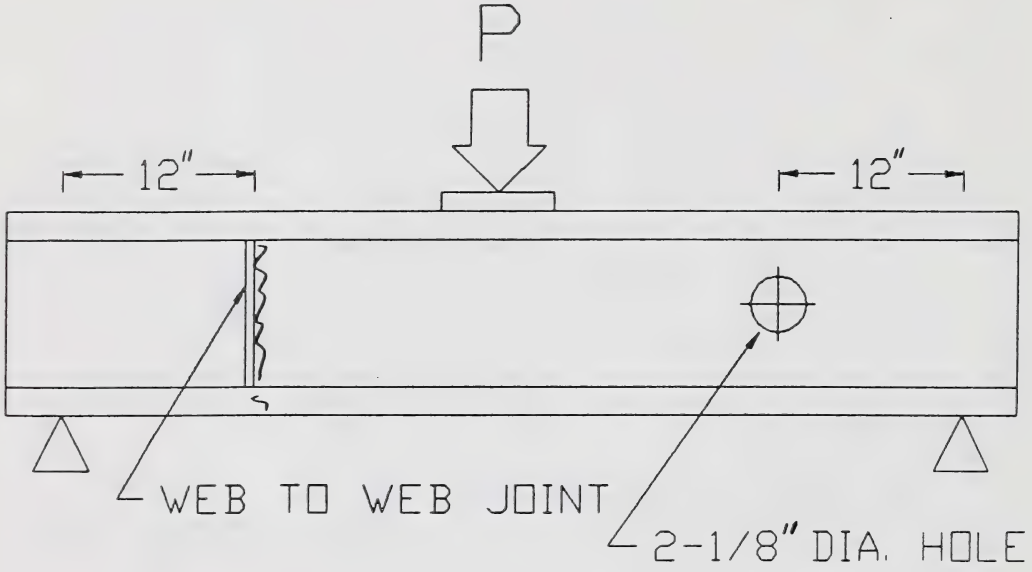
NOTES: Upper chord in compression

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJS12 DATE : AUG 31 1990

TEST NUMBER : 8 P MAX: 7920 lbs



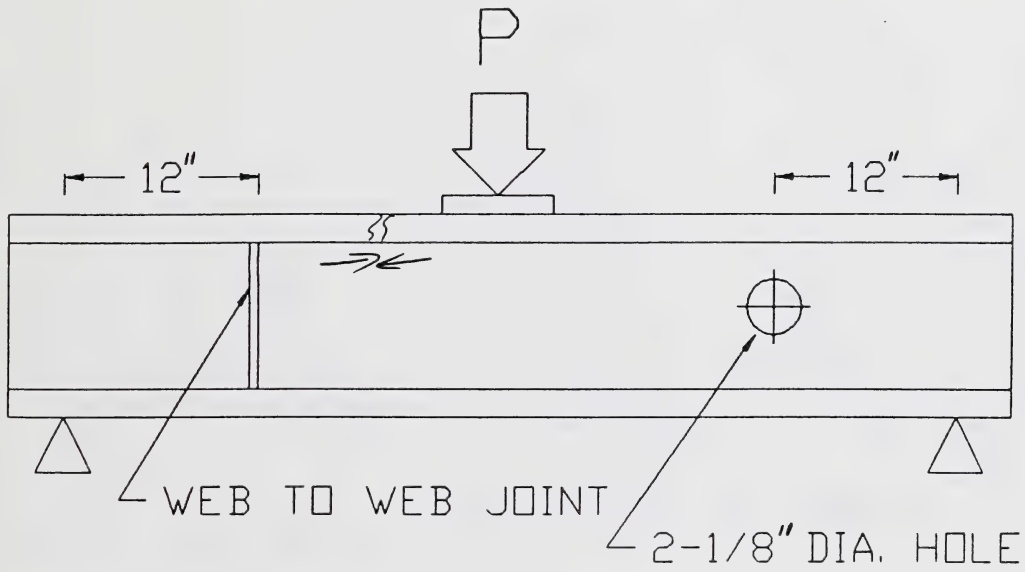
NOTES: Web to web joint in shear

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1
SHEAR TEST FAILURE MODE		OF 1
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJS12 DATE : AUG 31 1990

TEST NUMBER : 9 P MAX: 7395 lbs



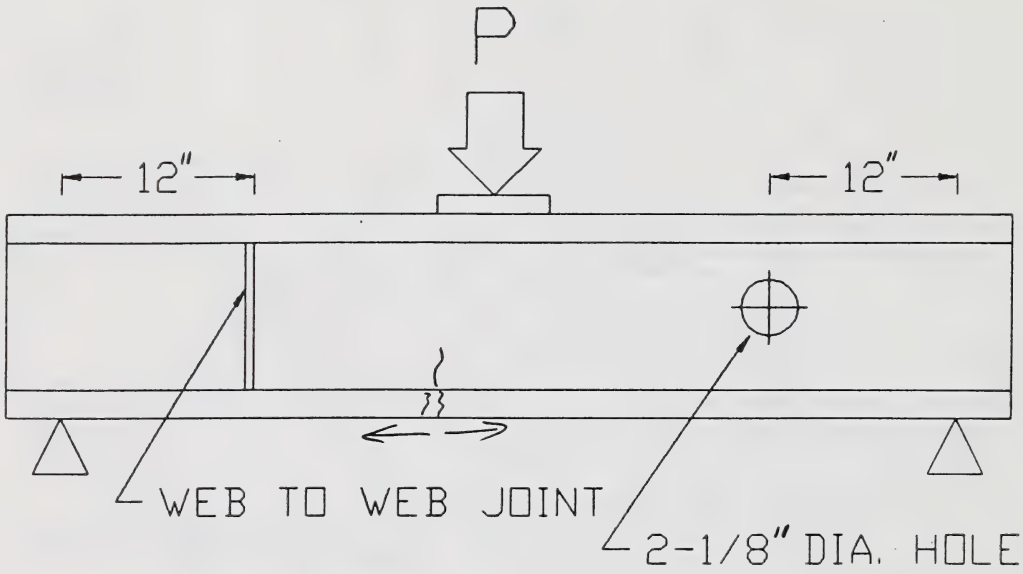
NOTES: Upper chord in compression.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJS12 DATE : AUG 3 1 1990

TEST NUMBER : 10 P MAX: 9340 lbs.



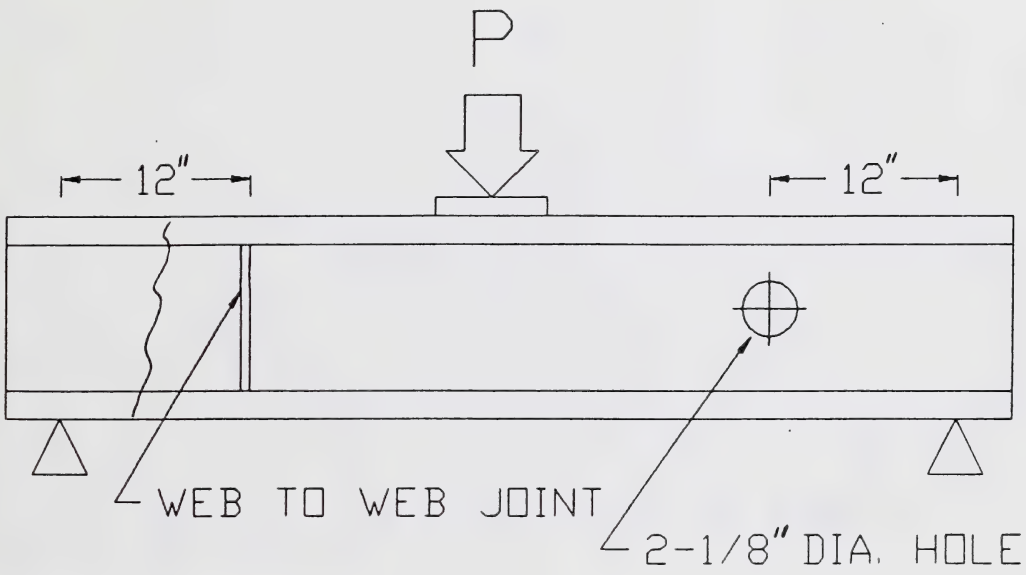
NOTES: Lower chord in tension.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJS12 DATE : AUG 31 1990

TEST NUMBER : 11 P MAX: 9165 165



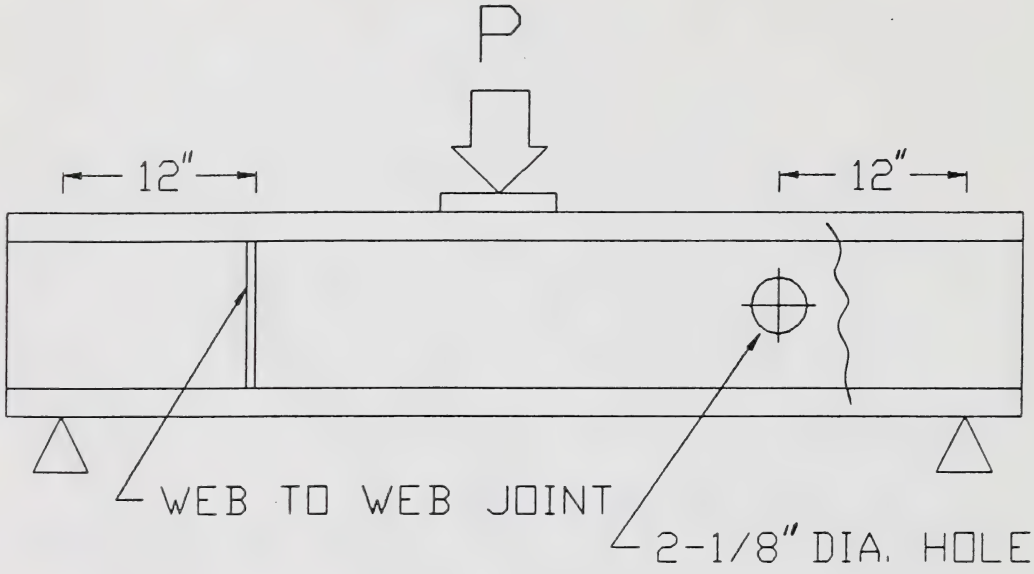
NOTES: Through joist in shear.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJS12 DATE : AUG 31 1990

TEST NUMBER : 12 P MAX: 8905 lbs.



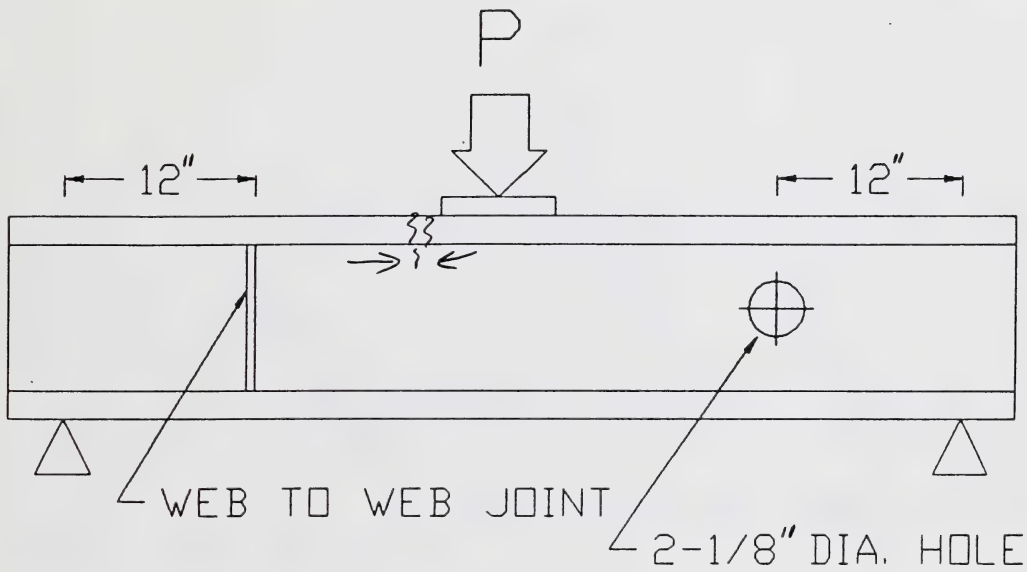
NOTES: Through joist in shear.

SHEAR CAPACITY TEST

NASCOR INCORPORATED	DWG. 1
SHEAR TEST FAILURE MODE	OF 1
DATE: 91-01-31 SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJS12 DATE : AUG 31 1990

TEST NUMBER : 13 P MAX: 8320 lbs



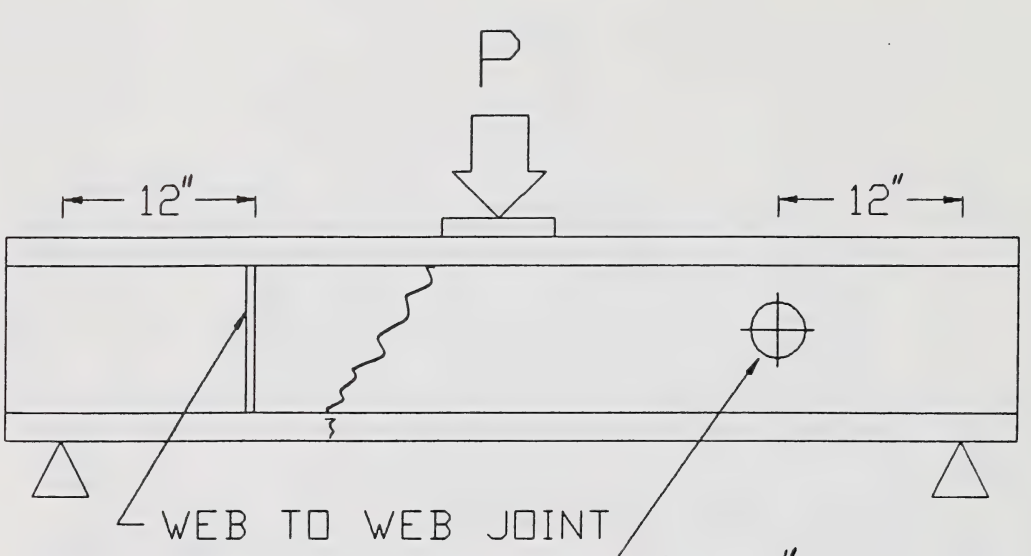
NOTES: Upper chord in tension

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJS12 DATE : AUG 31 1990

TEST NUMBER : 1A P MAX: 8905 lbs.



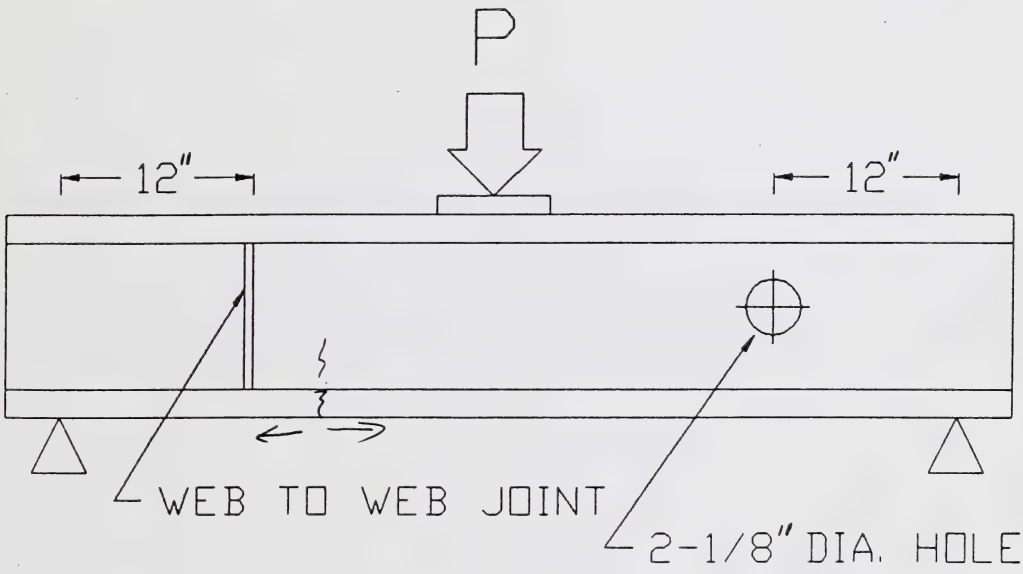
NOTES: Web in shear.

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

JOIST TYPE : NJS12 DATE : AUG 31 1990

TEST NUMBER : 15 P MAX: 8935 lbs.



NOTES: Lower chord in tension

SHEAR CAPACITY TEST

NASCOR INCORPORATED		DWG. 1 OF 1
SHEAR TEST FAILURE MODE		
DATE: 91-01-31	SCALE: N.T.S.	DWG. BY: P.A.

APPENDIX E Warnock Hersey Creep Performance Test Reports

Warnock Hersey Professional Services Ltd.
211 Schoolhouse St., Coquitlam, B.C. V3K 4X9 - (604) 520-3321 - Telecopier (604) 524-9186

REPORT OF: Wood Joist Structural Testing

AT: Coquitlam, B.C. DATE Aug. 7/90

PROJECT: 50485-C7-719500 REPORT NO: 2/90

REPORTED TO: Nascor Incorporated
7803P - 35 Street S.E.
Calgary, Alberta
T2C 1V3

ORDER NO.

Attention: Soa Hoang

INTRODUCTION

As requested, we have conducted physical tests on samples of wood joists submitted to our laboratory by Nascor Incorporated. The submitted wood joists were tested in accordance with the Canadian Construction Materials Centre (CCMC) Technical Guide for Prefabricated, Structural Wood Beams and Joists, Masterformat Section 06915, dated 90-01-15.

The wood joists were identified as NASCOR Model NJ 2x10 Joists with 2x3 Chords. The wood joists consisted of an oriented strand board (OSB) web with 2x3 SPF lumber chords. The chords were attached to the web on edge, forming a wood joist measuring 1.5 inches wide by 9.5 inches high (see drawing 1 in Appendix for the wood joist profile).

WOOD JOIST MATERIALS

1. **Chords -**

   The chords were 2x3 SPF 2100 MSR kiln dried lumber. The moisture content at the time of manufacturing and when tested was between 9 and 12 percent. The relative density of the SPF lumber chords was between 0.45 and 0.51. The moisture content was determined using the oven dry method based on the dry weight. The relative density measurement was conducted on the "wet" material by means of first measuring accurately cut samples followed by weighing them. The relative density was then calculated.

2. **Web -**

   The webs were 3/8 inch thick oriented strand board (OSB) manufactured by Weyerhaeuser Ltd. The moisture content of the OSB at the time of manufacturing and when tested was between 2 and 3 percent. The relative density of the Web material was between 0.65 and 0.70. The moisture content and relative density were determined in a similar manner as the SPF chords were.

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WOOD JOIST MATERIALS (continued)

3. Assembled Wood Joist -

The assembled wood joist measured 1.5 inches wide by 9.5 inches high. The combined unit weight of the wood joist was between 2.05 and 2.29 pounds per lineal foot.

WOOD JOIST FABRICATION

The oriented strand board (OSB) webs were cut to the required width using a table saw. The long edges of the webs were then fed through a taper mill that produced the tapered male part of the web to chord joint. One end of the 8 foot long web section had a male part of a tongue and groove joint and the other end had the female part of a tongue and groove joint.

Slots were cut into one edge of the SPF chord Lumber using a chord slotter. These slots received the tapered edge of the OSB web.

The slots were the same profile as the taper and measured 19.0 mm deep by 8.4 mm at the surface and 5.9 mm at the base. The web to chord and web to web joints were bonded using Phenol Resorcinol two part adhesive (LT75, FM265) manufactured by Borden Chemical.

Once the adhesive had been mixed, it was applied to the slots in the chords using the auto-gluer. The adhesive was applied to the male part of the web to web joint by dipping the male end of the 8 foot long web into the adhesive. The chords were placed on a conveyor table after the adhesive had been applied. The chords were then moved down the conveyor to the joist press.

Before the chords entered the press, they were set on flat and spread apart. A web section was then inserted into the slots of the chords at the end that enters the press first. The next web section was then fitted into the end of the first web section using the tongue and groove joint. Once enough web sections had been placed into the assembly, the entire joist assembly was then moved into the press where the components were pressed together to form the NASCOR joist.

Before the wood joist assembly was removed from the press, 25.4 mm (1 inch) staples were applied through the chords and web to hold the assembly together after removal from the press and before the adhesive set. The staples were applied to the top and bottom chords of the assembly on 24 inch centres.

The Nascor joists were then cured for a minimum of 24 hours in the plant at room temperature. All joists were at least one week old before being tested.

TEST METHOD

The wood joists were tested in pairs on 600 mm centres. Three pairs were tested. The joists were cross braced at one location at the middle of the span.

The top chords of the joists were sheathed with 18.5 mm thick Douglas Fir plywood in 600 mm wide by 1200 mm long sections. The plywood sheets were placed with the face grain at right angles to the top chords. A 2 mm gap was left between the sheets of plywood. The sheathing was nailed to the top chords using 51 mm long common nails on 150 mm spacing. A small piece of plywood was also attached between each end of the bottom cord to stabilize the assembly.

The deflections at the centre span of each member were measured using taut wires against graduated scales. The scales used were graduated in 1 mm increments. The wires were kept taut using springs. Parallax errors were avoided using small mirrors fastened to the members behind the wires. Deflections were measured and recorded to the nearest 0.5 mm.
The loads were applied using standard 200 mm x 200 mm x 400 mm concrete building blocks previously weighed using a calibrated scale. The blocks were applied gently and at a steady rate to the test assembly.

The joists were tested on a 4725 mm (186 inch) span (see Drawing 2 in Appendix).

TEST RESULTS

Test Load	Weight (kN/m^2)	Time	Deflection Test 1	Test 2	Test 3
Step 2	0.0	0 sec	0.0 mm	0.0 mm	0.0 mm
Step 3(a)	0.5	300 sec	2.0 mm	2.0 mm	1.5 mm
3(b)	0.5	300 sec	4.0 mm	4.0 mm	3.5 mm
3(c)	2.0	3600 sec	12.5 mm	12.5 mm	12.5 mm
Step 4	2.0	24 hours	12.5 mm	13.0 mm	14.5 mm
Step 5	0.0	300 sec	6.0 mm	5.5 mm	6.0 mm
Step 6	6.0	24 hours	n/a	n/a	n/a

The three joist assemblies met the following requirements of the CCMC Technical Guide for Prefabricated, Structural Wood Beams and Joists, Masterformat Section 06195:

Section 5.1 - The maximum difference in the deflections measured in step 2 and step 3(c) did not exceed 1/360 of the span or 13 mm, whichever is smaller. (1/360 of the span is 13.1 mm)

- The difference in the deflection at any one point as measured in step 4 did not exceed 25 percent of the deflection measured in step 3(c).

TEST RESULTS (continued)

- The maximum difference in the deflections measured in step 3(b) and step 5 did not exceed 1/1440 of the span. (1/1440 of the span is 3.3 mm)

- The systems survived the load exerted in step 6 without collapse.

CONCLUSION

The wood joists submitted to our laboratory by Nascor Incorporated identified as NASCOR NJ 2x10 Wood Joists with 2x3 Chords met the Acceptable Performance requirements of section 5.2 of the Canadian Construction Materials Centre Technical Guide for Prefabricated, Structural Wood Beams and Joists, Masterformat Section 06195 on a 4725 mm (186 inch) span.

WARNOCK HERSEY PROFESSIONAL SERVICES LTD.

Reported by:

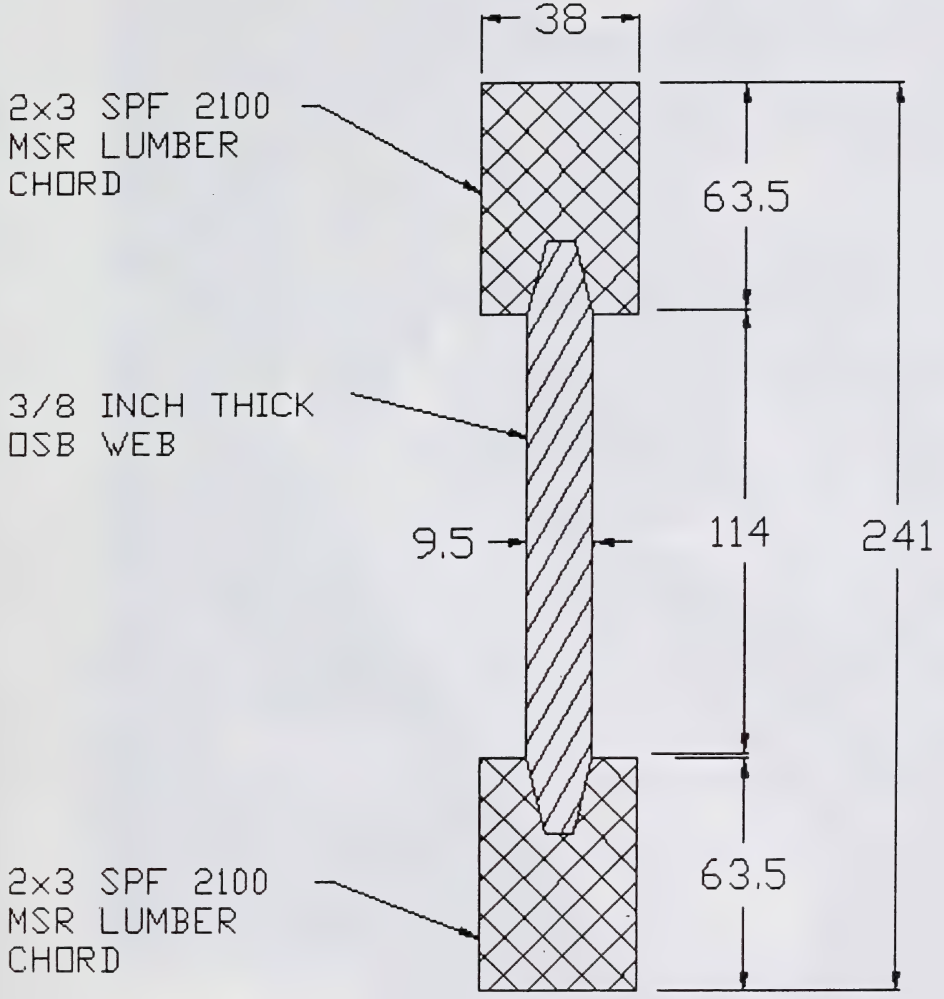
Doug Docherty
Technician
Materials Testing Division

Reviewed by:

Lawrence Gibson, P.Eng.
Laboratory Manager

dd/aml

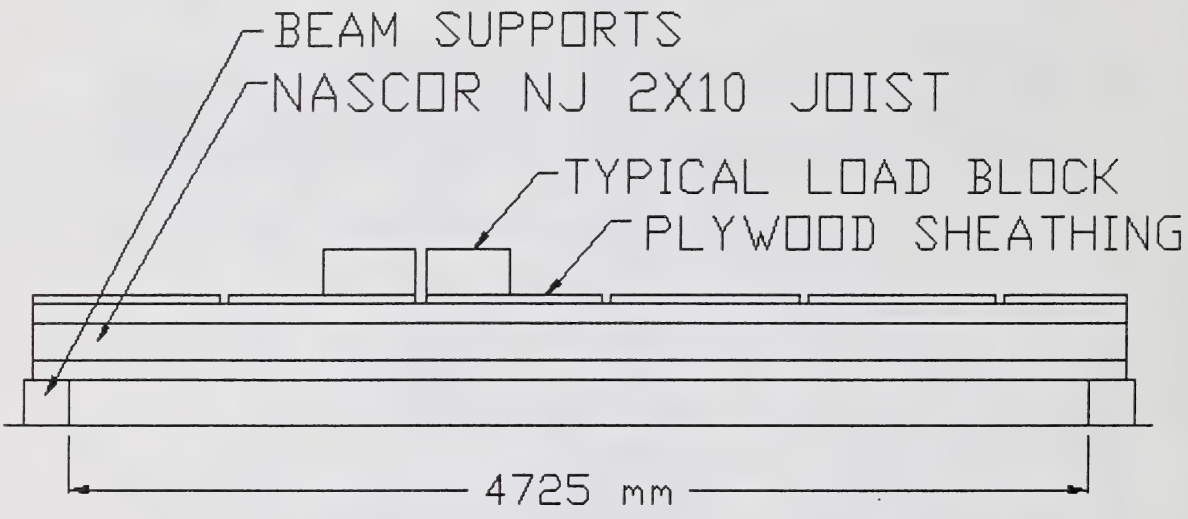
cc: Ron Waters - CCMC



SECTION THROUGH JOIST

NASCOR INCORPORATED		DWG. 1 OF 2
NJ 2X10 WOOD JOISTS		
JULY 30, 1990	SCALE: N.T.S.	DRG. BY: PA

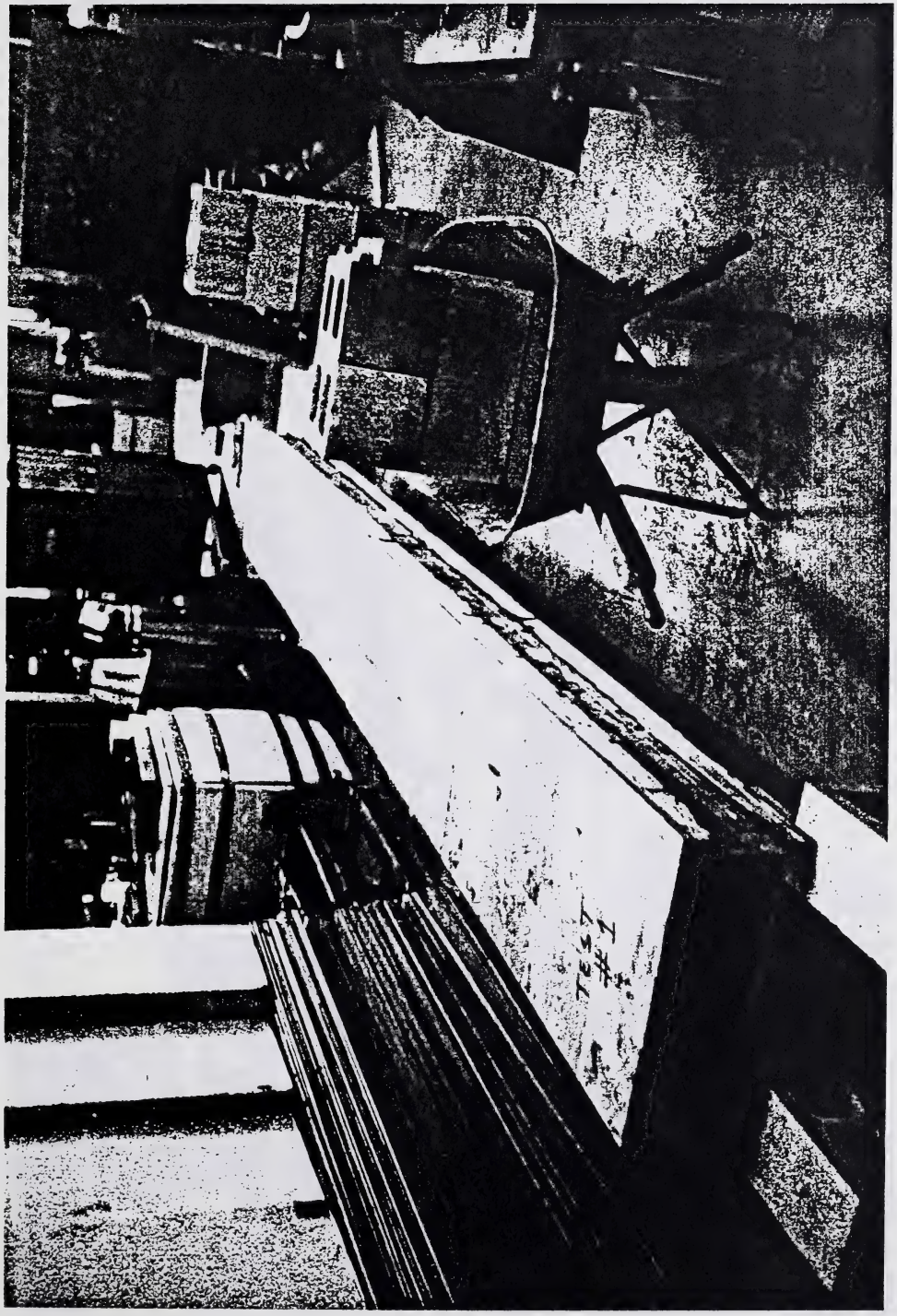
TEST CONFIGURATION



NASCOR INCORPORATED		DWG. 2 OF 2
NJ 2X10 WOOD JOISTS		
JULY 30, 1990	SCALE: N.T.S.	DRG. BY: PA

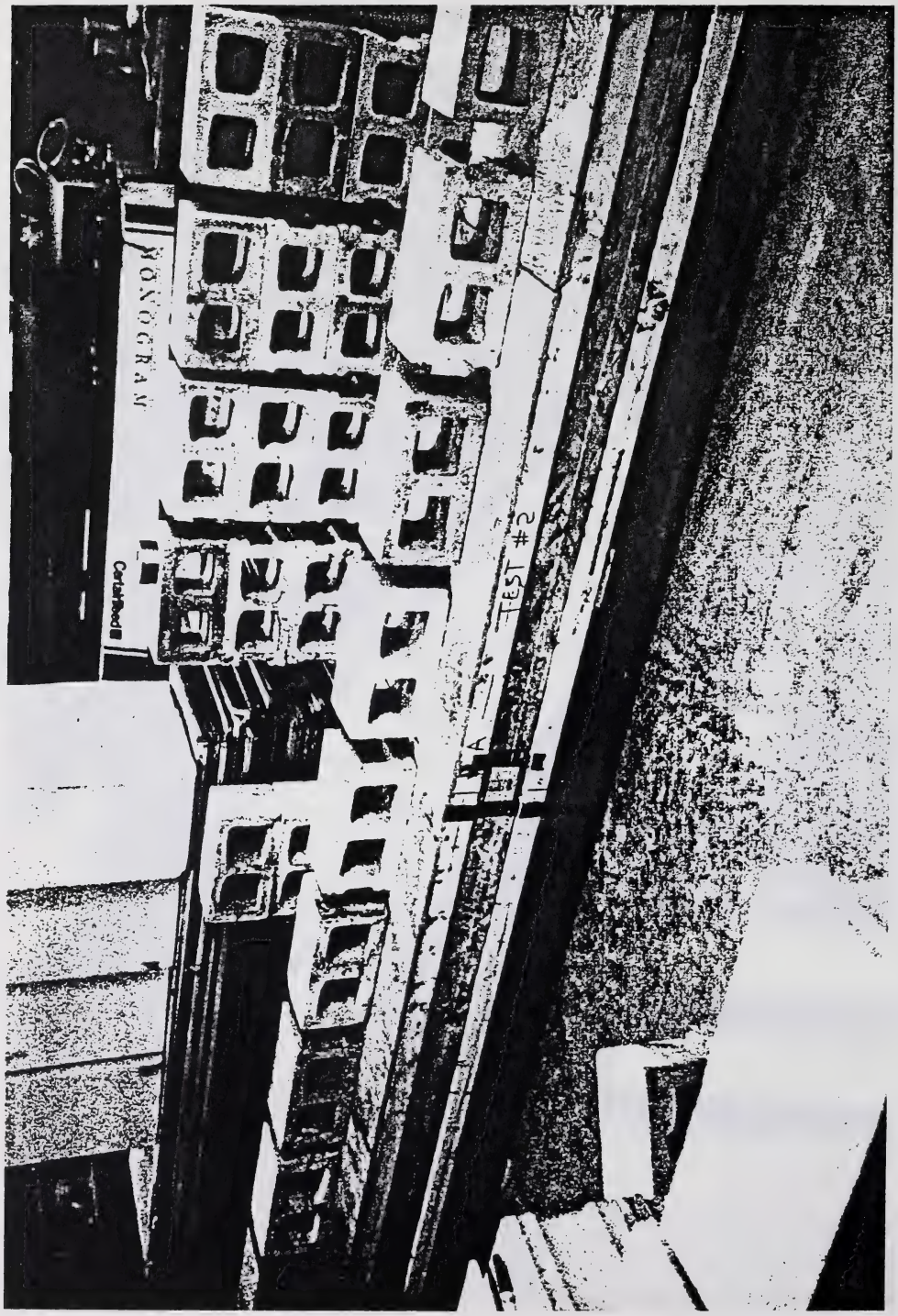
Nascor Incorporated
Report No. 2/90/08/07
Photo #1

Nascor NJ 2x10
Wood Joists - Load Test Assembly



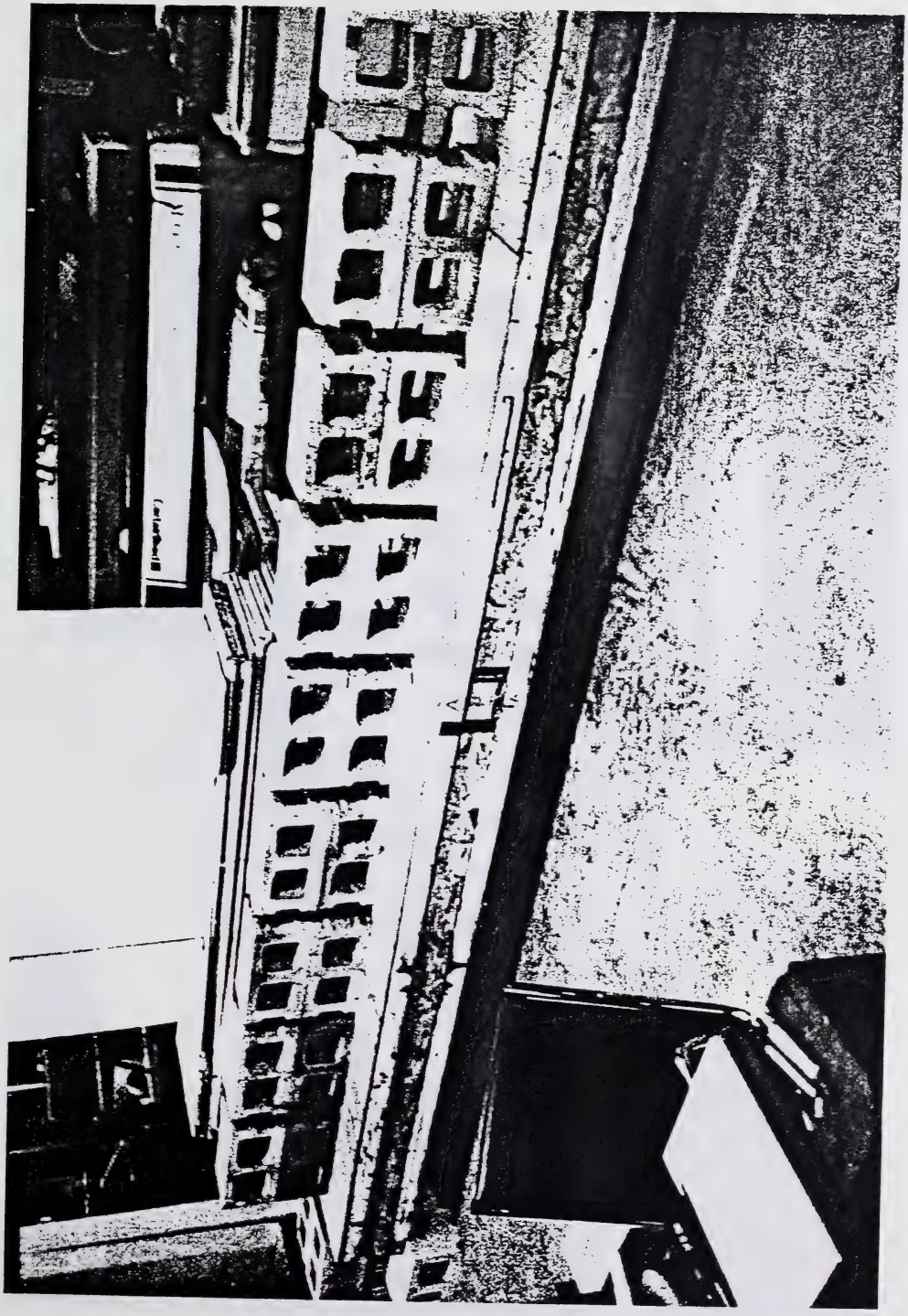
Nascor Incorporated
Report 2/90/08/07
Photo #2

Nascor NJ 2x10
Wood Joists - Load Test Step 3 (a) 0.5 Kn/m^2



Nascor Incorporated
Report No. 2/90/08/07
Photo #3

Nascor NJ 2x10
Wood Joists - Load Test Step 3 (b) 1.0 Kn/m^2



Nascor Incorporated
Report No. 2/90/08/07
Photo #4

Nascor NJ 2x10
Wood Joists - Load Test Step 3 (c) & 4 3.0 Kn/m^2

Nascor Incorporated
Report No. 2/90/08/07
Photo #5

Nascor NJ 2x10
Wood Joists - Load Test Step 6 6.0 Kn/m^2

Warnock Hersey Professional Services Ltd.
211 Schoolhouse St., Coquitlam, B.C. V3K 4X9 - (604) 520-3321 - Telecopier (604) 524-9186

REPORT OF: Wood Joist Structural Testing

AT: Coquitlam, B.C. DATE Aug. 28/90

PROJECT: 50485-C7-719500 REPORT NO: 3/90

REPORTED TO: Nascor Incorporated
7803P - 35 Street S.E.
Calgary, Alberta
T2C 1V3

ORDER NO.

Attention: Soa Hoang

INTRODUCTION

As requested, we have conducted physical tests on samples of wood joists submitted to our laboratory by Nascor Incorporated. The submitted wood joists were tested in accordance with the Canadian Construction Materials Centre (CCMC) Technical Guide for Prefabricated, Structural Wood Beams and Joists, Masterformat Section 06915, dated 90-01-15.

The wood joists were identified as NASCOR Model NJ 2x12 Joists with 2x3 Chords. The wood joists consisted of an oriented strand board (OSB) web with 2x3 SPF lumber chords. The chords were attached to the web on edge, forming a wood joist measuring 1.5 inches wide by 11.875 inches high (see drawing 1 in Appendix for the wood joist profile).

WOOD JOIST MATERIALS

1. **Chords -**

   The chords were 2x3 SPF 2100 MSR kiln dried lumber. The moisture content at the time of manufacturing and when tested was between 9 and 12 percent. The relative density of the SPF lumber chords was between 0.45 and 0.51. The moisture content was determined using the oven dry method based on the dry weight. The relative density measurement was conducted on the "wet" material by means of first measuring accurately cut samples followed by weighing them. The relative density was then calculated.

2. **Web -**

   The webs were 3/8 inch thick oriented strand board (OSB) manufactured by Weyerhaeuser Ltd. The moisture content of the OSB at the time of manufacturing and when tested was between 2 and 3 percent. The relative density of the Web material was between 0.65 and 0.70. The moisture content and relative density were determined in a similar manner as the SPF chords were.

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WOOD JOIST MATERIALS (continued)

3. Assembled Wood Joist -

The assembled wood joist measured 1.5 inches wide by 11.875 inches high.

WOOD JOIST FABRICATION

The oriented strand board (OSB) webs were cut to the required width using a table saw. The long edges of the webs were then fed through a taper mill that produced the tapered male part of the web to chord joint. One end of the 8 foot long web section had a male part of a tongue and groove joint and the other end had the female part of a tongue and groove joint.

Slots were cut into one edge of the chord SPF Lumber using a chord slotter. These slots received the tapered edge of the OSB web. The slots were the same profile as the taper and measured 19.0 mm deep by 8.4 mm at the surface and 5.9 mm at the base.

The web to chord and web to web joints were bonded using Phenol Resorcinol two part adhesive (LT75, FM265) manufactured by Borden Chemical.

Once the adhesive had been mixed, it was applied to the slots in the chords using the auto-gluer. The adhesive was applied to the male part of the web to web joint by dipping the male end of the 8 foot long web into the adhesive. The chords were placed on a conveyor table after the adhesive had been applied. The chords were then moved down the conveyor to the joist press.

Before the chords entered the press, they were set on flat and spread apart. A web section was then inserted into the slots of the chords at the end that enters the press first. The next web section was then fitted into the end of the first web section using the tongue and groove joint. Once enough web sections had been placed into the assembly, the entire joist assembly was then moved into the press where the components were pressed together to form the NASCOR joist.

Before the wood joist assembly was removed from the press, 25.4 mm (1 inch) staples were applied through the chords and web to hold the assembly together after removal from the press and before the adhesive set. The staples were applied to the top and bottom chords of the assembly on 24 inch centres.

The Nascor joists were then cured for a minimum of 24 hours in the plant at room temperature. All joists were at least one week old before being tested.

TEST RESULTS (continued)

- The maximum difference in the deflections measured in step 3(b) and step 5 did not exceed 1/1440 of the span. (1/1440 of the span is 3.7 mm)
- The systems survived the load exerted in step 6 without collapse.

CONCLUSION

The wood joists submitted to our laboratory by Nascor Incorporated identified as NASCOR NJ 2x12 Wood Joists with 2x3 Chords met the Acceptable Performance requirements of section 5.2 of the Canadian Construction Materials Centre Technical Guide for Prefabricated, Structural Wood Beams and Joists, Masterformat Section 06195 on a 5334 mm (210 inch) span.

WARNOCK HERSEY PROFESSIONAL SERVICES LTD.

Reported by: _____

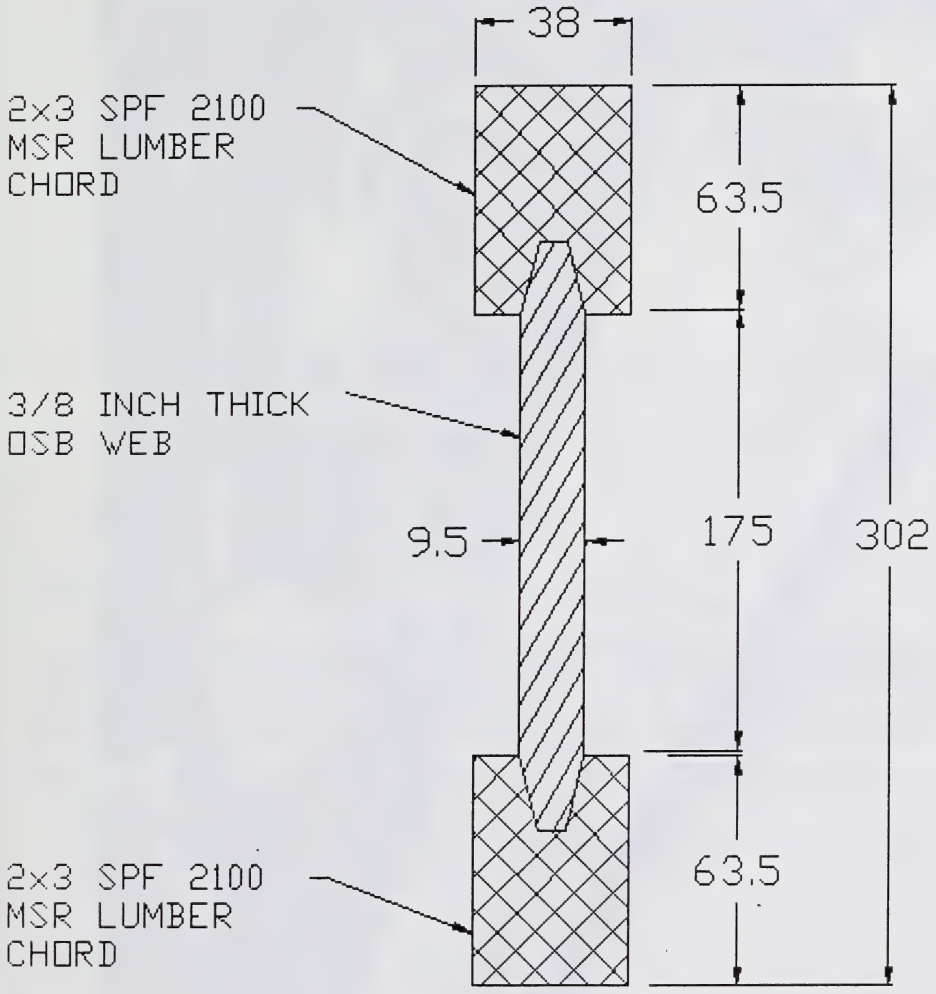
Paul Arnold
Supervisor
Materials Testing Division

Reviewed by: _____

Lawrence Gibson, P.Eng.
Laboratory Manager

dd/aml

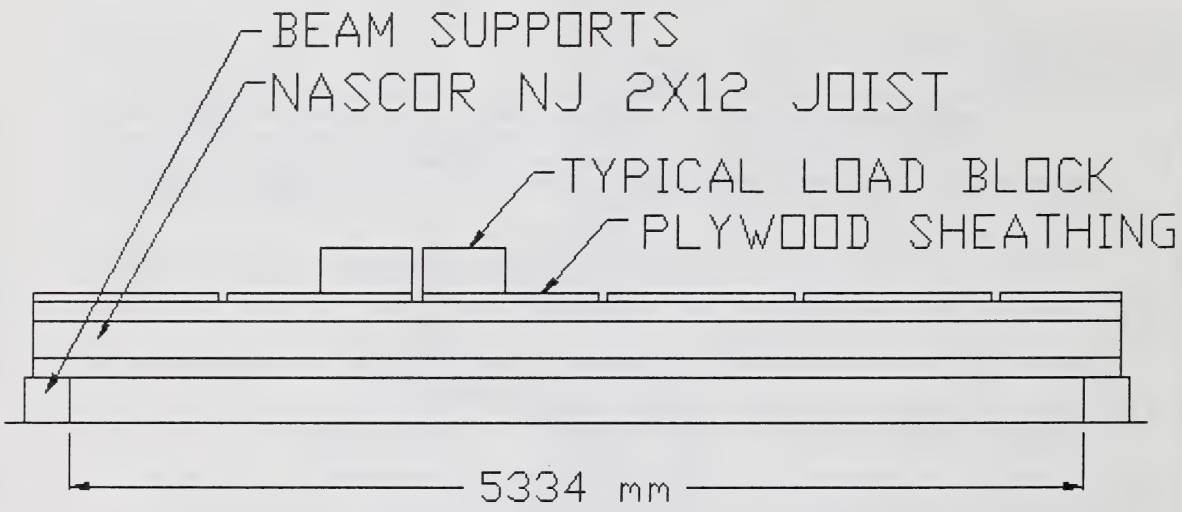
cc: Ron Waters - CCMC



SECTION THROUGH JOIST

NASCOR INCORPORATED		DWG. 1 OF 2
NJ 2X12 WOOD JOISTS		
AUG. 28, 1990	SCALE: N.T.S.	DRG. BY: PA

TEST CONFIGURATION



NASCOR INCORPORATED		DWG. 2 OF 2
NJ 2X12 WOOD JOISTS		
AUG. 28, 1990	SCALE: N.T.S.	DRG. BY: PA

Nascor Incorporated
Report no. 3/90/08/28

Photo 1

Nascor NJ 2 X 12 Wood Joists

Load Test Assembly

Nascor Incorporated
Report no. 3/90/08/28

Photo 2

Nascor NJ 2 X 12 Wood Joists

Load Test Step 3(a) 0.5 kn/m^2

Nascor Incorporated
Report no. 3/90/08/28

Photo 3

Nascor NJ 2 X 12 Wood Joists

Load Test Step 3(b) 1.0 kn/m^2

Nascor Incorporated
Report no. 3/90/08/28

Photo 4

Nascor NJ 2 X 12 Wood Joists

Load Test Steps 3(c) and 4 3.0 kn/m^2

Nascor Incorporated
Report no. 3/90/08/28

Nascor NJ 2 X 12 Wood Joists

Load Test Step 6 6.0 kn/m^2

Warnock Hersey Professional Services Ltd.
211 Schoolhouse St., Coquitlam, B.C. V3K 4X9 - (604) 520-3321 - Telecopier (604) 524-9186

REPORT OF: Wood Joist Structural Testing

AT: Coquitlam, B.C. DATE Aug. 7/90

PROJECT: 50485-C7-719500 REPORT NO: 1/90

REPORTED TO: Nascor Incorporated
7803P - 35 Street S.E.
Calgary, Alberta
T2C 1V3

ORDER NO.

Attention: Soa Hoang

INTRODUCTION

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The wood joists were identified as NASCOR Model NJ 2x12 Joists with 2x4 Chords. The wood joists consisted of an oriented strand board (OSB) web with 2x4 SPF lumber chords. The chords were attached to the web on edge, forming a wood joist measuring 1.5 inches wide by 11.875 inches high (see drawing 1 in Appendix for the wood joist profile).

WOOD JOIST MATERIALS

1. **Chords -**

   The chords were 2x4 SPF 2100 MSR kiln dried lumber. The moisture content at the time of manufacturing and when tested was between 9 and 12 percent. The relative density of the SPF lumber chords was between 0.45 and 0.51. The moisture content was determined using the oven dry method based on the dry weight. The relative density measurement was conducted on the "wet" material by means of first measuring accurately cut samples followed by weighing them. The relative density was then calculated.

2. **Web -**

   The webs were 3/8 inch thick oriented strand board (OSB) manufactured by Weyerhaeuser Ltd. The moisture content of the OSB at the time of manufacturing and when tested was between 2 and 3 percent. The relative density of the Web material was between 0.65 and 0.70. The moisture content and relative density were determined in a similar manner as the SPF chords were.

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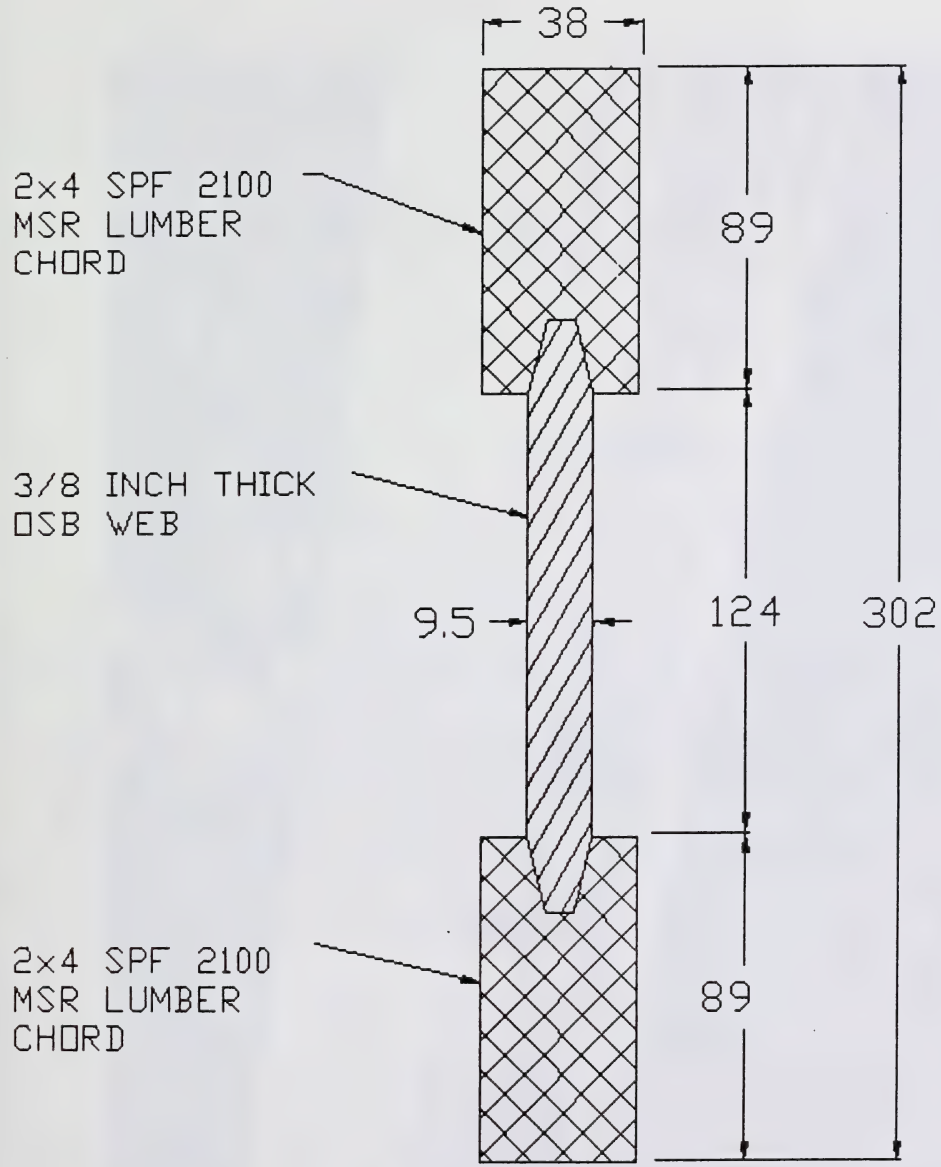
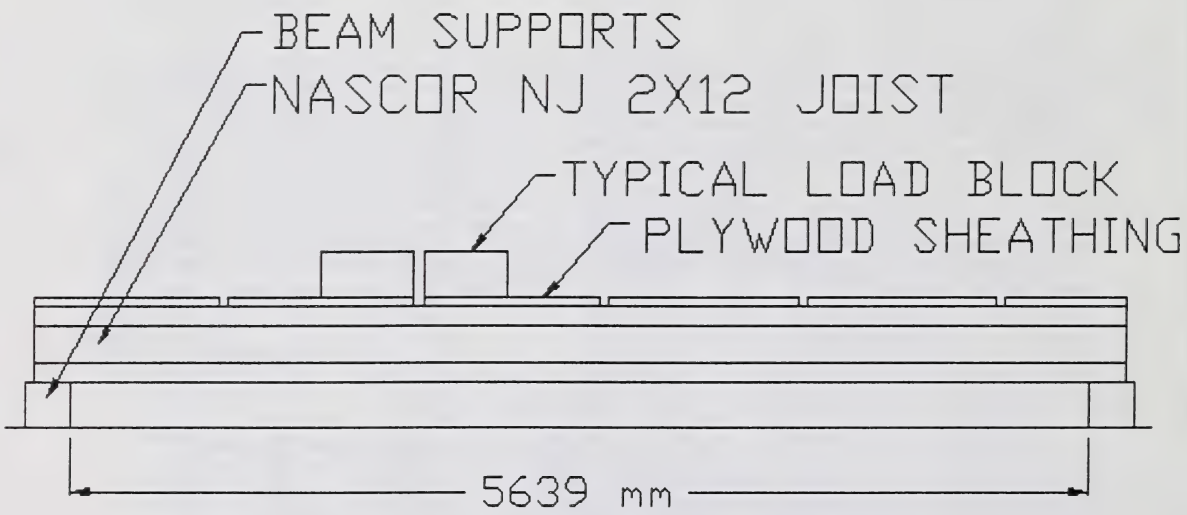


SECTION THROUGH JOIST

NASCOR INCORPORATED		DWG. 1 OF 2
NJ 2X12 WOOD JOISTS		
JULY 30, 1990	SCALE: N.T.S.	DRG. BY: PA

TEST CONFIGURATION



NASCOR INCORPORATED		DWG. 2 OF 2
NJ 2X12 WOOD JOISTS		
JULY 30, 1990	SCALE: N.T.S.	DRG. BY: PA

Nascor Incorporated
Report No. 1/90/08/07
Photo #1

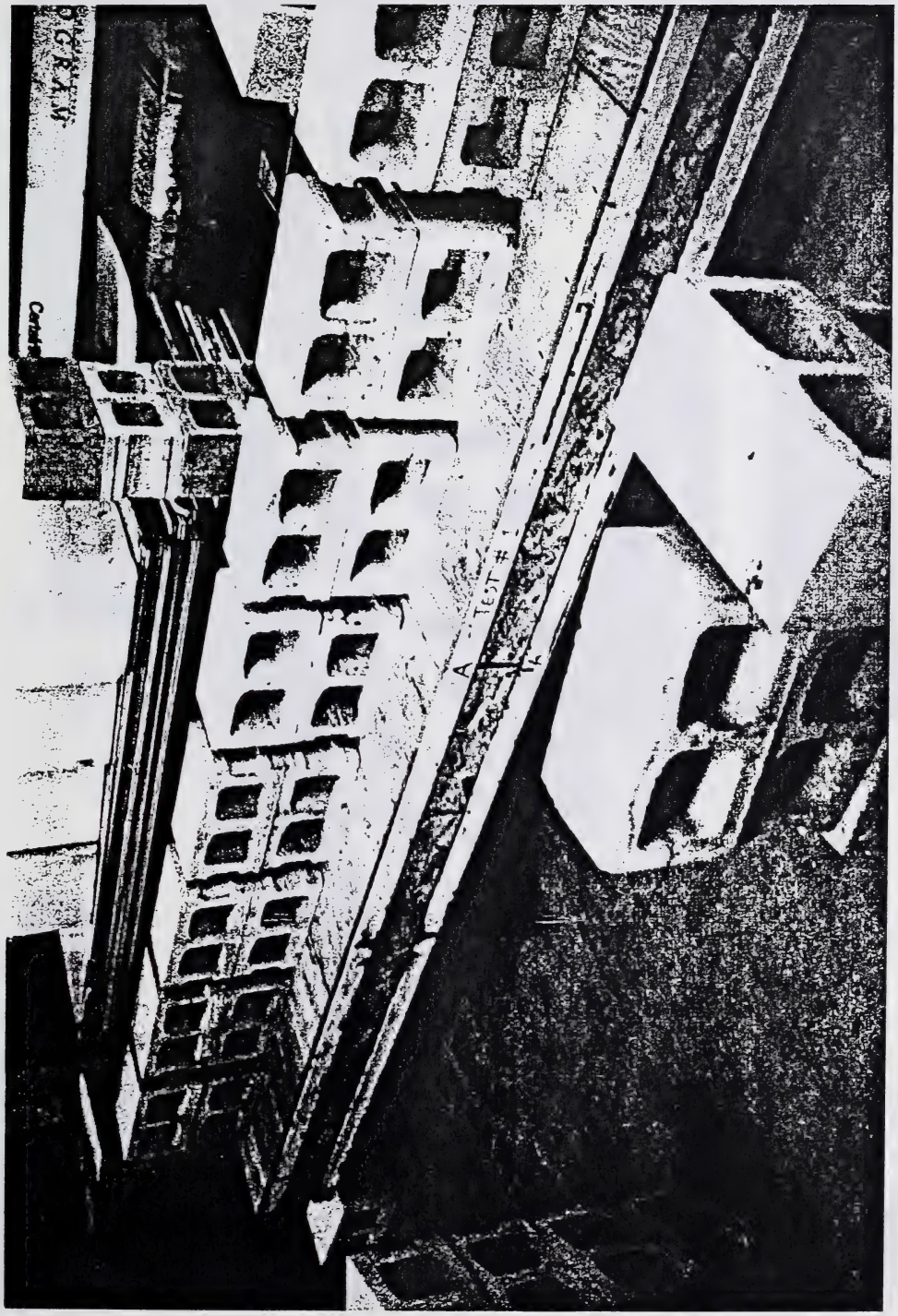
Nascor NJ 2x12
Wood Joists - Load Test Assembly

Nascor Incorporated
Report No. 1/90/08/07
Photo #2

Nascor NJ 2x12
Load Test Step 3(a) 0.5 Kn/m²

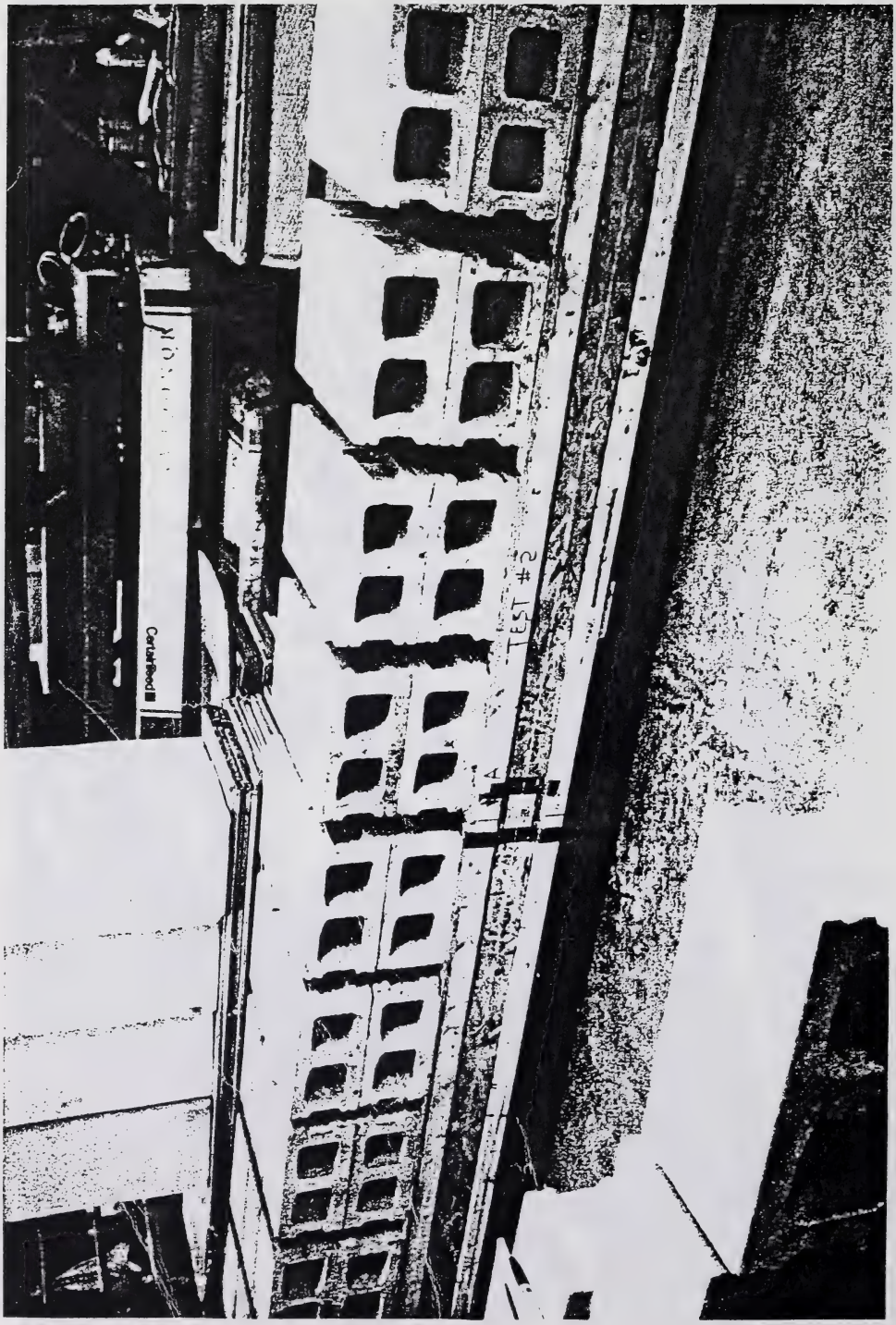
Nascor Incorporated
Report No. 1/90/08/07
Photo #3

Nascor NJ 2x12
Wood Joists - Load Test Step 3(b) 1.0 Kn/m²



Nascor Incorporated
Report No. 1/90/08/07
Photo #4

Nascor NJ 2x12
Wood Joists - Load Test Step 3(c) and 4 3.0 Kn/m²



Nascor Incorporated
Report No. 1/90/08/07
Photo #5

Nascor NJ 2x12
Wood Joists - Load Test Step 6 6.0 Kn/m²